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HEALTH, SAFETY AND ENVIRONMENT DEPARTMENT
ENVIRONMENTAL SCIENCES BRANCH
PROGRESS REPORT FOR JANUARY-JUNE 1980

Douglas C. Hunt, Group Manager
John D. Hurley, Report Coordinator

Rockwell International

Energy Systems Group
Rocky Flats Plant
P.O. Box 464
Golden, Colorado 80401

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ENVIRONMENTAL SCIENCES BRANCH PROGRESS REPORT FOR JANUARY-JUNE 1980

ABSTRACT

This report summarizes activities of the Environmental Studies and Environmental Analysis Groups during the period January through June 30, 1980. Four major projects are reported; namely, dust transport including filter efficiency studies, distribution of transuranics in sediment, critical ecological pathways for radionuclides, and ecosystem compartmentalization of transuranics. Progress is described for the special programs dealing with management of open space lands at Rocky Flats, assurance of quality in environmental monitoring measurements, assessment of epidemiological studies of health effects purported to be related to the Plant, and evaluation of environmental monitoring data. Some of the reported project activities on Rocky Flats Plant site include studies of (1) airborne dust concentration and specific americium-241 activity in the field east of the asphalt pad, (2) vertical fluxes of dust in the same field, (3) vertical sediment sampling profiles of plutonium-239, -240 and americium-241 in the Great Western Reservoir spillway, (4) radiological sediment sampling of water bodies on and near the Plant site, (5) measured frequency and coverage values of representative plant species and their importance values for two test plots near the Plant, (6) transuranic specific activities of vegetation from the same two test plots, (7) airborne deposition and root uptake of transuranics by plants at the Lindsay Ranch Pond and the greenhouse site, and (8) tissue analysis (for transuranics) of deer road-killed near or on the Plant site.

SUMMARY

The principal findings in the major group programs may be summarized as follows.

1. Dust Transport and Filter Efficiency—The dust transport studies concentrated on the rate of plutonium resuspension by wind erosion from the field directly east of the asphalt pad area. Four cyclone/impactor air samplers were installed along the perimeter of this field and were operated continuously to follow the airborne concentration of plutonium and to establish the relation between dust particle size and activity. Soil surface activity of plutonium was measured in the field and ranged from 40 to 1200 pCi Pu/g soil.

   Filter penetration measurements were made both on polystyrene (Microsorban®) and fiberglass (Gelman®) filter media by challenging them with a plutonium oxalate aerosol. These tests were inconclusive because of the inability to generate sufficient quantities of aerosol.

2. Distributions of Transuranics in Sediment—Results of vertical profile sediment sampling and radioanalysis are reported for samples obtained from the spillway of a reservoir downgradient of Rocky Flats. No differences between the sample activity levels and background levels were seen. A program of general radiological sediment sampling of waterbodies on and near the Plant site was initiated during this reporting period. The plan for the project was written and approved and the necessary experimental equipment (boat components and the coring device plus accessories) was acquired.

3. Ecological and Radioecological Characterization of Terrestrial Ecosystems—A complete ecological vegetation community analysis was done and reported for two 100 m × 100 m study plots northeast and southeast of the Plant. A differential collection of vegetation from the two study plots was made for biomass estimation and radionuclide analysis. Also,

radioanalytical results from vegetation collected in 1979 are reported. No unusual activity levels were observed. The northeast plot showed near background values, and the southeast plot values were a few times greater than background.

4. Critical Ecological Pathways Program—This program includes (1) studies of airborne deposition and root uptake of transuranics by plants grown within and outside of a greenhouse located on soil containing about 100 d/m/g plutonium activity and (2) tissue analysis (for transuranics) of deer that were road-killed on or near the Plant site. Progress during this reporting period included (1) installation of the greenhouse and associated equipment, (2) establishment of three test plots (within the greenhouse, near the greenhouse, and in a control area), (3) vegetation and soil sampling on the test plots, and (4) acquisition and installation of a muffle furnace for ashing the deer tissue.

Progress in programs dealing with Plant site Land Management, quality assurance plans, air sampler calibrations, and environmental monitoring data evaluations is also described.

INTRODUCTION AND OBJECTIVES

The purpose of this report is (1) to summarize briefly the progress of research activities within the Environmental Sciences Branch during the first half of CY 1980, (2) to provide current status of these activities, and (3) where appropriate, to supply the anticipated future directions for these and other potential Branch programs.

The overall research objective of the Environmental Sciences Branch is to provide scientific research data of high quality that can assist the Health, Safety and Environment Department (of which the Environmental Sciences Branch is a subgroup) in its mission of evaluating and controlling the impact of the Rocky Flats Plant on the Plant's surroundings. To accomplish this, a few salient projects from the great variety possible have been selected and are being actively pursued by the ES Branch. These projects involve efforts in the general areas of radioecological distributions, physical transport of radioactivity, and land use. Also included is assistance to the Environmental Sciences Branch in the area of establishing a pilot program for evaluating current monitoring efforts. More specifically, progress and results in the following areas are summarized in this report.

1. Emission rates and transport of airborne radioactivity as a function of the nature of the windblown resuspending disturbance, the localized activity distribution in the soil, the radionuclides involved, the host dust particle size distribution, and the moisture content and vegetative cover of the soil.

2. Collection efficiency of various filter media for airborne radioactivity.

3. Sampling and analysis for transuranics and other radionuclides in sediments and adjacent soils of ponds and reservoirs on and near the Plant.

4. Radiological and nonradiological assessments of ecosystem differences on terrestrial study plots having different levels of transuranic soil activity.

5. Studies concerning biological pathways for radionuclide transport from the environment to the individual. These include discussions and descriptions of programs involving measurements of radionuclide uptake by vegetation on Plant lands containing transuranic activity and analysis of tissue from deer road-killed on or near the Plant.

6. Land Management practices on Plant lands, including the status of Plant Land-Use Requests and a review of the 1980 Plant program for remote sensing data acquisition.

7. Monitoring and evaluations of epidemiological studies and their data bases concerning

population health effects related to the Plant and to other nuclear facilities.

8. Interpretations and evaluations of radioanalytical data for water and air samples taken on or near the Plant site, including an evaluation of the relationship between biochemical oxygen demand and total organic carbon concentrations in Plant sanitary wastewater effluents.

9. Review of current progress toward assurance of quality in environmental monitoring measurements.

10. A list of Environmental Sciences Branch publications and presentations.

DUST TRANSPORT AND RESUSPENSION

Windblown Resuspension

Gerhard Langer

INTRODUCTION

The object of this study is to quantify the process of soil erosion by wind that resuspends small amounts of plutonium contaminated soil particles in the atmosphere and transports them in the environs of Rocky Flats. During this reporting period, a 120 X 152 m field east of the asphalt pad* and adjacent to it was studied. Windblown resuspension of soil from this field is presumed to be the source of most of the airborne plutonium detected by air samplers S7, S8, and S9 shown in Figure 1.

FIDLER SURVEY

Using a FIDLER (Field Instrument for the Detection of Low-Energy Radiation) instrument, the field was surveyed for areas with greater than background levels of transuranic activity. Only for activity above the background level of about 300 counts per minute does the FIDLER give a quantitative indication of plutonium-239, -240 in terms of the associated americium-241 activity (White and Dunaway, 1978, pp. 361–404). As shown in Figure 1, only a few areas in the field are contaminated above 300 cpm, and the 13 soil samples where taken in the areas of highest activity. The soil samples (1-8, R1-2, and F1-3) were analyzed to quantify the FIDLER survey.

*A 3.4-acre onsite plot of contaminated soil that has been stabilized by covering it with layers of fill dirt, gravel, and asphalt.

RESUSPENDIBLE DUST SAMPLER

As reported in the 1979 Environmental Studies Annual Report (Hunt and Hurley, 1981), a resuspendible dust sampler for simulating wind erosion of soil was assembled and tested in the field. The sampler collects and fractionates samples for radioactivity analysis. Problems were encountered with this sampler because the airflow above the soil surface could not be controlled to simulate natural wind forces. That is, at times a scouring effect was noted after a soil surface was exposed to the wind tunnel.

During this reporting period, the wind tunnel was redesigned as shown in Figure 2 and was recently field tested.

The new wind tunnel is much more adaptable to uneven soil surface contours and has a larger test section. The tunnel now maintains controlled, parallel airflow above the surface, without a tendency for a suction effect as found in a vacuum cleaner, and thus better simulates natural wind forces.

Soil particles are separated by the resuspendible dust sampler into three particle size fractions: (1) the preseparator cyclones remove the coarse, non-inhalable (> 10 μm) particles, (2) the cascade impactor collects samples of inhalable particles (< 10 μm), and (3) the backup filter traps the respirable (< 3 μm) particles. Using both the cyclones and the impactor sharpened the cutoff for

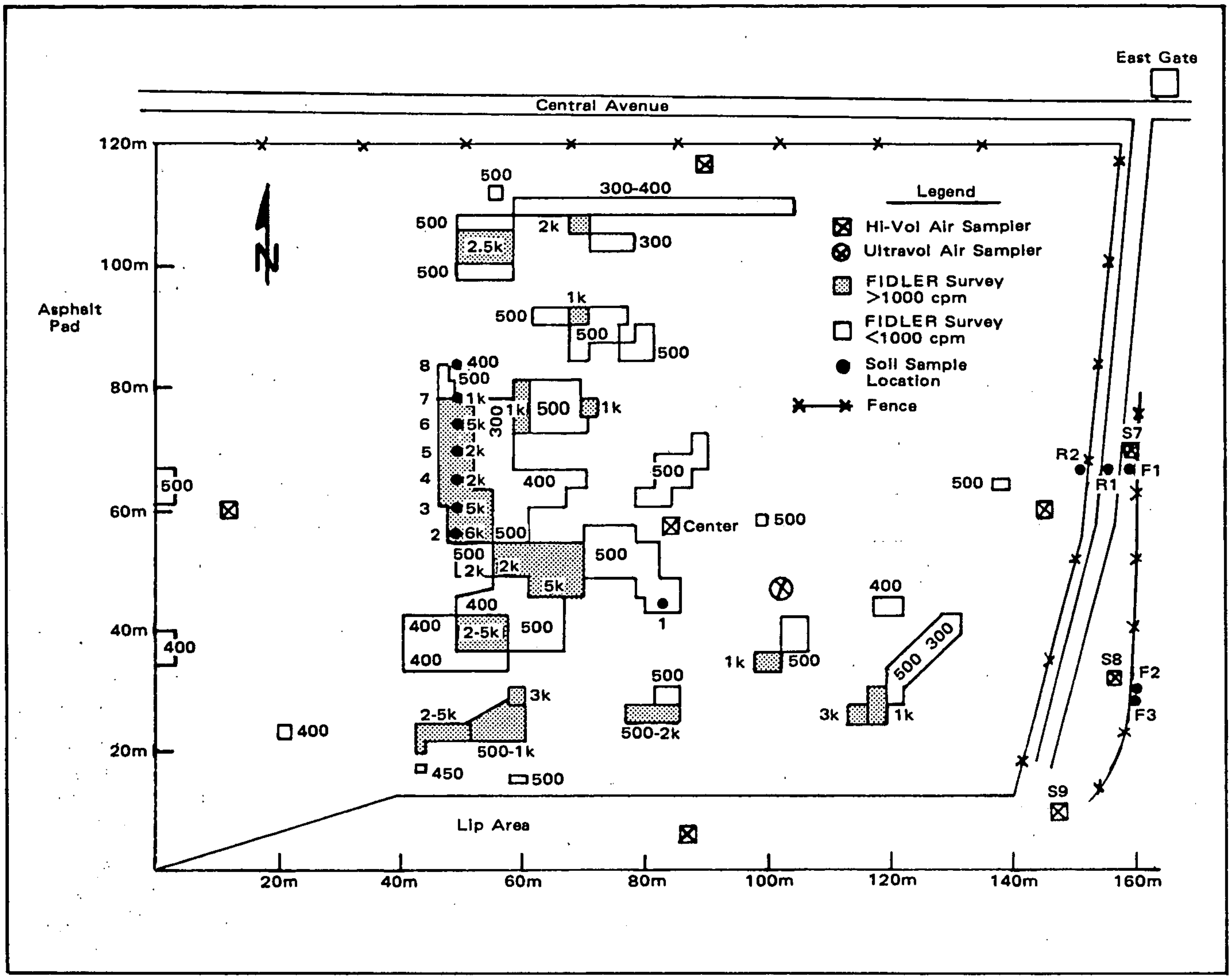

FIGURE 1. Results of FIDLER Survey of the Open Field East of the Pad. Only the areas indicated had activity levels above background; that is, greater than 300 cpm.

the coarse particles at approximately 3-μm aerodynamic diameter and prevented bounce-through to the backup filter. Only particles of respirable size reached the backup filter. Additional impactor stages were not used because there were too few particles collected in the 0.5–3.0 μm range for radioactivity analysis of several size fractions.

The redesigned wind tunnel has not yet been used in a contaminated area. The original wind tunnel was operated in the field east of the pad for the first time in December 1979, and the americium-241 activity of the collected dust samples was reported in the 1979 Annual Report (Hunt and Hurley, 1981). Resuspended dust and soil samples from the same sampling site were examined during this period by nuclear track films. The results showed qualitatively that the coarse fraction of the resuspended dust had more activity per unit mass than the undisturbed soil because of the absence of larger soil particles in the dust. The plutonium particles themselves ranged in size from 0.2 to 0.6 μm in diameter. A few particles may have approached 10 μm and would have accounted for a significant portion of the total

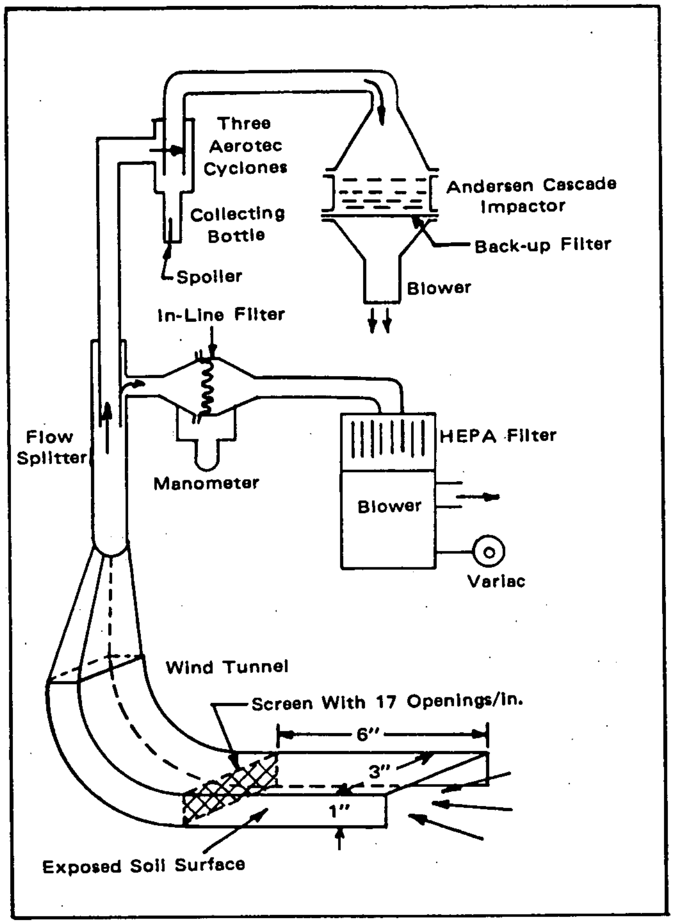

FIGURE 2. Resuspendible Dust Sampler With Redesigned Wind Tunnel

activity. Work was done to isolate a few of the larger more radioactive particles for direct examination by high-resolution electron microprobe. The object was to resolve whether the plutonium in such a particle was present as one solid particle or as an agglomerate of fine, loose particles. The one test made indicated that the plutonium was in the form of a loose agglomerate. A previous test by J. A. Hayden of Chemistry Research gave a similar result. The respirable fraction (< 3 μm) of the resuspended dust had plutonium particles limited to the 0.1- to 0.3-μm range.

HIGH-VOLUME AIR SAMPLING

To integrate data from the resuspendible dust sampler into a viable model for windblown resuspension of dust at Rocky Flats, it is also necessary to measure the plutonium particles entrained by air passing over the suspected source area. Sierra® High-Volume (Hi-Vol) samplers, modified as described in the 1979 Annual Report (Hunt and Hurley, 1981), were located on each boundary and in the center of the east field as shown in Figure 1. Stages 1 and 2 from a 5-stage impactor improved the cyclone cutoff enough that a sharp respirable fraction was collected. The remaining three stages were not used because the amount of activity collected on each stage would be too low to detect. By correlating data from the air samplers with wind direction data, the source of the activity may be verified. Table 1 summarizes the data for the first 1-month sampling run in June 1980 with the four Hi-Vol samplers. The respirable dust mass fractions are quite constant, but the coarse fractions from the north and east samplers are about 30 percent higher than the coarse fractions from the other two samplers. The north and east samplers are near unpaved roads, and samples indicate that the airborne radioactivity increases as the road is approached. This raises the question as to whether the field east of the pad is the controlling source of the airborne plutonium. These data represent the first set of a 12-month sampling run to explore the above trends.

The four Sierra Hi-Vol samplers cannot identify the specific meteorological events that resuspend the dust particles because the samplers must be operated continuously for 4 weeks before samples with measurable activity can be collected. The activity can only be correlated to averaged wind data. Therefore, to identify particular meteorological events with amounts of resuspended dust activity, a new ultrahigh-volume air sampler (shown in Figure 3) was developed at Rocky Flats and placed into operation. With the increased sampling volume, measurable levels of activity can be collected in a few days at a flow rate of about 123 ℓ/s (260 cfm), which is 6-1/2 times the Sierra Hi-Vol rate. The "ultravol" is designed with a filtration area identical to the standard high-volume filter. The compact filtration area is achieved through a special filter combination. A foam-plastic (polyurethane) prefilter, treated with vaseline as an adhesive, acts as a high-capacity dust filter to remove particles > 10 μm in diameter. The fine fraction passing the prefilter is collected on a low-resistance filter (IPC 1478), which must operate

TABLE 1. Airborne Americium-241 Activity Measured at Perimeters of the East Field (May 29-June 28, 1980)

Sampler Location	Dust Concentration ($\mu g/m^3$) Respirable[a]	Coarse	Specific Activity (pCi/g) Respirable[a]	Coarse	Airborne Concentration (aCi/m^3)[b] Coarse
West edge of field	9	63	< MDA[c]	0.3	19
North edge of field[d]	10	84	< MDA	0.6	62
East edge of field	9	83	< MDA	0.9	83
South edge of field	9	64	1	0.7	55

a. Particles < 3 μm in diameter.
b. Attocurie per cubic meter.
c. Minimum Detectable Activity.
d. Operated only to June 9.

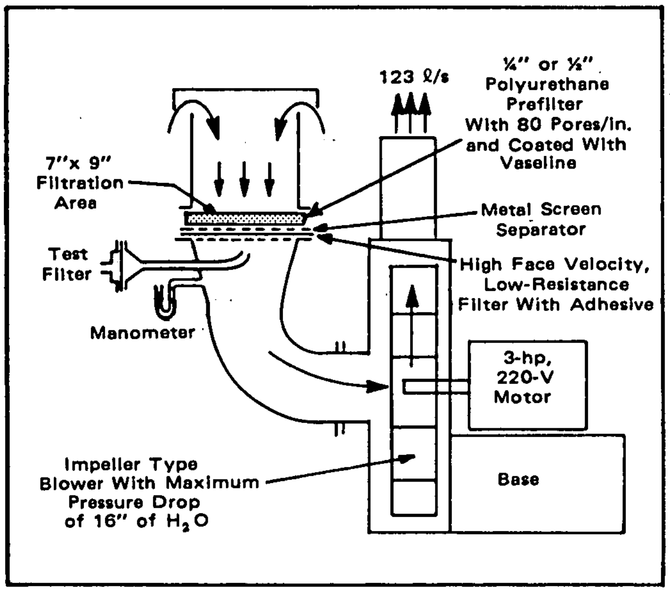

FIGURE 3. Rocky Flats' Ultrahigh-Volume Air Sampler

at a high face velocity of about 6 m/s (1200 ft/min) to be efficient (Stafford and Ettinger, 1971).

VERTICAL FLUX OF DUST

Another important phase of the dust transport project is the collection of data on the vertical flux of dust to determine the extent of the downwind transport. The vertical flux usually is determined by measuring the aerosol concentration at different heights downwind of a source area. A vertical flux dust tower with Sierra Hi-Vol samplers was located in an open field just west of the pad to measure the upward flow of particles smaller than 50 μm in diameter. A Bagnold catcher (Gillette and Goodwin, 1974) next to the tower monitors the rise of sand-sized particles (⩾ 500 μm) to a height of 1 m or less. During high winds that originate from the west, this field should provide basic data for dust resuspension by wind in the Rocky Flats area. Two air samplings were made of the field using four

TABLE 2. Vertical Dust Flux Measurement Using Sierra Hi-Vol Samplers

Sampler Location	Sampler Height (m)	Dust Concentration ($\mu g/m^3$) Feb. 27–April 10, 1980 Coarse	Fine[a]	April 17–May 21, 1980 Coarse	Fine[a]
Dust Tower	6.0	15	8	21	11
Dust Tower	1.5	16	8	25	11
Center of East Field	1.5	22	7	28	12
East Fence	1.5	58	9	61	13

a. Particles < 3 μm in diameter.

Sierra Hi-Vol samplers. Two samplers were placed on the tower, one was placed in the center of the field east of the pad, and one was placed along the fence east of the field. The data are presented in Table 2.

For dust from a local source, it is expected that the concentration of dust would decrease with height because (1) particles that become airborne near the receptor cannot rise sufficiently high to be captured and (2) at higher levels the rate of airflow past the receptor increases. Consequently, the dust rising to higher levels should be diluted. Samples taken at 6.0 and 1.5 m on the tower showed no vertical flux of dust. Samples taken in the east field and at the east fence indicated upward movement for coarse particles but not for fines. This latter observation (no change in the concentration of the fines), points to a local source of coarse material, namely a nearby unpaved road. The other two samplers to the east also showed input from road traffic and windblown bare areas as judged by the enhanced amount of coarse material in respect to fines. It is clear that other sources of dust predominate over dust raised from the field by wind erosion. Consequently, vertical flux measurements based purely on dust concentration data cannot predict the rise of dust from the field east of the pad due to wind erosion. The plutonium content of the dust from the field must be used to study vertical flux.

WIND PROFILE MEASUREMENTS

The vertical flux dust tower was also instrumented with three anemometers at 0.15, 1.0, and 6.0 m heights to obtain wind profile data. Winds near the surface control dispersion of airborne materials in conjunction with ground surface cover and relief. The wind profile is usually expressed in a logarithmic form that also defines the friction velocity (Slade, 1968). The friction velocity is necessary for resuspension and deposition calculations.

Wind profiles were obtained during two windstorms. On February 19, maximum winds reached 34, 36, and 50 mph at 0.15, 1.0, and 6.0 m, respectively. A surface roughness of 0.6 cm was derived from the data, assuming a logarithmic wind profile. This agrees with published data for the sparse grass ground cover as found at the Plant site (Slade, 1968).

SALTATING PARTICLE COUNTING

Work on this project has shown a need for understanding microphysics of soil particle release by wind erosion to develop a predictive dust transport model. In the 1979 Annual Report (Hunt and Hurley, 1981) an automatic saltating particle counter was described. The counter detects the movement of particles greater than 50 μm in diameter when they are released from the soil surface by wind and then bounce along the surface. The device was operated during the windstorm on February 19 in the field west of the pad. Winds reached speeds of up to 34 mph at the 0.15-m height, and the onset of wind erosion (generation of fine particles by impact of large particles), occurred at wind speeds of 20 mph. Again, the rate of particle generation was rather low, and little wind erosion could be expected from this field. This low

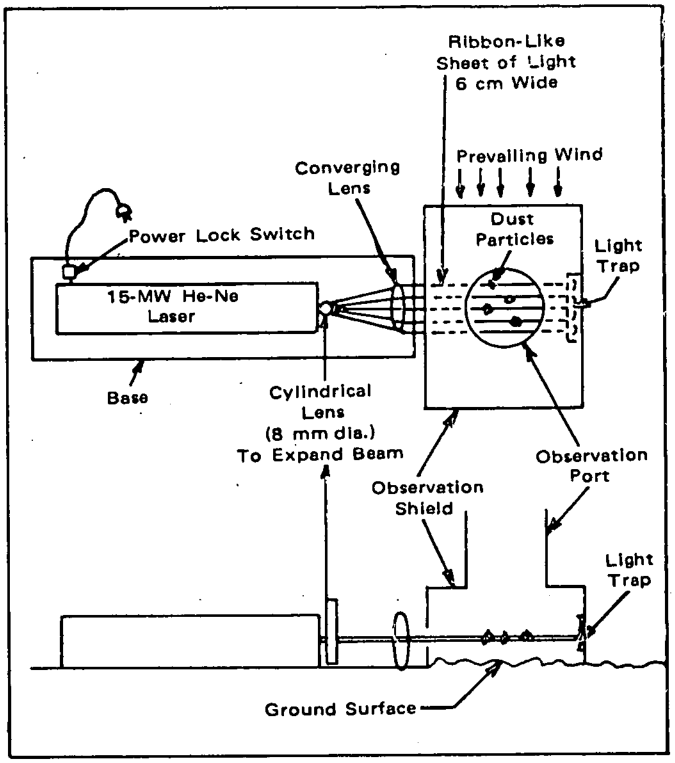

FIGURE 4. Laser Optics to Observe > 1-μm Soil Particles Eroded and Suspended by Wind

erosion rate is verified by the vertical dust flux measurements discussed in a prior section of this report.

Further studies will be made of the generation of fine particles by the impact of saltating particles using a He-Ne laser-camera device. The laser is aimed along the surface of the soil, and particles of at least 1 μm in diameter are photographed when they intersect the beam. The smaller particles are of special interest because they are respirable. A field system was assembled during this period based on the laboratory tests reported in the 1979 Annual Report (Hunt and Hurley, 1981). Figure 4 shows the assembly that is ready for field testing.

Filter Efficiency Studies

Gerhard Langer

INTRODUCTION

The project objective is to verify, under operating conditions, the efficiency of filter media used for environmental monitoring at Rocky Flats. The 1979 efforts on this project verified the reported 99% efficiency of the Delbag Microsorban® 98 Grade S polystyrene filter and the Gelman® Type E fiberglass filter under various field operating conditions. Direct particle counts made of the filters using a condensation nucleus counter indicated that no filter penetration occurred for particle concentrations ranging from 5,000 to 30,000 particles per cubic centimeter. Measurements made on the efficiency of the filters for radioactive particles typical of Plant effluent were not conclusive because there was not enough radioactivity in the effluent from several stages of HEPA filters to challenge the filter papers in series. A test aerosol made by burning metallic plutonium did not produce enough airborne plutonium for filter testing.

PLUTONIUM OXALATE AEROSOLS

During the present reporting period, another attempt was made to generate a plutonium aerosol, but by burning a salt of plutonium oxalate instead of metallic plutonium. According to J. A. Hayden (1972) this should produce a well-defined, aerosol of < 1.0-μm particles. One gram of the salt was heated to red heat in a glove box. The salt oxidized but no direct combustion occurred and no visible smoke formed. Nevertheless, the air above the heated salt was sampled by drawing the air through a test filter with a 50-cm^3 syringe. The results were inconclusive due to either cross contamination of the back-up filter during disassembly of the filter holder or a leak in the check valves of the syringe sampler system that would force radioactive particles directly onto the back-up filter. The experiment needs to be repeated with improved precautions against back-up filter contamination.

Because heating the plutonium salt was not easily controlled and the amount of aerosol produced was too low, another approach for aerosol generation will be tried. This approach should produce a more concentrated and nearly monodispersed aerosol of $\approx$0.3-μm particles. Instead of a syringe, a pump will be used to obtain the air sample to avoid the check valve leakage problems. The proposed procedure is to atomize 1 cm^3 of a solution containing a few milligrams of a plutonium salt using a disposable medical atomizer. Then the partially evaporated solution droplets will be passed through silica gel to produce dry salt particles in the submicron range. The test filter should collect activity over 100,000 disintegrations per minute (dpm), taking into account the losses in the silica gel dryer.

NUCLEAR TRACK ANALYSIS

The size distribution of particles collected on the test filter will be determined with nuclear track measurements. This work with radioactive aerosols will allow refinement of the technique for determining filter efficiencies with nuclear tracks, which can be quantitative with proper care (Buddemeier, 1978). Nuclear track analysis offers the most promise as a tool for verifying filter penetration by low-level radioactive aerosols from Plant effluents.

SEDIMENT SAMPLING

Great Western Reservoir Spillway Sediment Sampling Program Phase II

John D. Hurley

INTRODUCTION

Sampling and radioactivity analysis of the sediment that accumulated at the entrance to the Great Western Reservoir spillway was conducted at the request of the Rocky Flats Area Office, Department of Energy. The project was divided into two phases. Phase I of the project was completed March 16, 1979 and consisted of analyses of 5-cm-deep surface samples and 23-cm-deep shallow core samples for activity levels of plutonium-239, -240 and americium-241 and the activity variation in the sediment at 14 sampling sites. The results showed that the transuranic activity levels in these samples were near regional fallout background levels. The details of the analyses are reported in the Phase I Report (Hurley, 1981).

Phase II, accomplished on March 11, 1980, was conducted prior to removal of the spillway sediment and was made to determine the historical deposition of plutonium in the sediment. The data will aid in

FIGURE 5. Sample Collection Procedure Using a Standard Orchard Auger

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the modeling of transuranic distributions for this deposition mode. Phase II consisted of a series of horizontal core samples taken from the vertical surface of a 3-m wall of accumulated sediment. The samples making up this vertical profile also were analyzed for plutonium-239, -240, and americium-241. The sampling procedures and analyses are reported herein and were conducted according to established Rocky Flats procedures.

PHASE II SAMPLING

The second and final phase of the sampling program involved obtaining seven samples from the vertical surface of a 3-m-high sediment wall.

All samples were taken from the accumulated sediment located at the eastern end of the GWR spillway that is supported by nine 15 cm X 30 cm X 3.5 m wooden stoplogs. A 30-cm^2 section was cut from each stoplog to provide easy access to the desired sampling area and yet support for the 3-m sediment wall was maintained.

Seven samples were then extracted at 30-cm intervals down the accumulated sediment wall, and each sample extended approximately 16 cm into the sediment. A standard Orchard Auger* (with an 8.3-cm-diameter, 16-cm-long barrel) was used to extract each sample as shown in Figure 5. A volume of about 750 cm^3 of soil was obtained for each sample.

*Standard Type #R-HEO, ARTS Machine Shop, American Falls, Idaho.

TABLE 3. Alpha Analysis of Plutonium-239 -240 in Great Western Reservoir Spillway

Location[a]	Plutonium-239, -240 (pCi/g)
AO+00 C9-1	0.055 ± 0.011
AO+00 C9-2	0.070 ± 0.017
AO+00 C9-3	0.068 ± 0.013
AO+00 C9-4	0.048 ± 0.011
AO+00 C9-5	0.018 ± 0.006
AO+00 C9-6	0.016 ± 0.007
AO+00 C9-7	0.006 ± 0.005
$\overline{X}$[b]	0.040
S[c]	0.026

a. Samples taken to a 9-ft depth down sediment wall at site AO+00 C9. Samples 1 through 7 extracted at 30-cm intervals down the wall.
b. $\overline{X}$ is mean plutonium concentration.
c. S is standard deviation.

TABLE 4. Alpha Analysis of Americium-241 in Great Western Reservoir Spillway

Location[a]	Americium-241 (pCi/g)
AO+00 C9-1	0.055 ± 0.040
AO+00 C9-2	0.063 ± 0.043
AO+00 C9-3	0.055 ± 0.041
AO+00 C9-4	0.038 ± 0.038
AO+00 C9-5	0.058 ± 0.041
AO+00 C9-6	0.117 ± 0.048
AO+00 C9-7	0.063 ± 0.035
$\overline{X}$[b]	0.064
S[c]	0.025

a. Samples taken to a 9-ft depth down sediment wall at site AO+00 C9. Samples 1 through 7 extracted at 30-cm intervals down the wall.
b. $\overline{X}$ is mean plutonium concentration.
c. S is standard deviation.

TABLE 5. Gamma Analysis of Americium-241 in Great Western Reservoir Spillway

Location[a]	Americium-241[b] (pCi/g)
AO+00 C9-1	< 0.067
AO+00 C9-2	< 0.092
AO+00 C9-3	< 0.069
AO+00 C9-4	< 0.098
AO+00 C9-5	< 0.087
AO+00 C9-6	< 0.077
AO+00 C9-7	< 0.015

a. Samples taken to a 9-ft depth down sediment wall at site AO+00 C9. Samples 1 through 7 extracted at 30-cm intervals down the wall.
b. All measurements were below the minimum detectable concentration level. Results listed are the MDC levels, thus accounting for the absence of mean and standard deviation values.

SAMPLE PRETREATMENT AND ANALYSIS

Samples were handled and analyzed according to Rocky Flats laboratory procedures. The procedures included drying, ball milling, and sieving of the collected material before taking 10-g aliquots for alpha and gamma spectral analyses. Control samples prepared at the two-sigma level were also submitted for alpha analysis to determine the quality of the results. Alpha analyses of all samples were performed in duplicate and were blank corrected.

RESULTS

The plutonium-239, -240 and americium-241 activity levels determined by chemical separation followed by alpha spectral analysis are given in Tables 3 and 4, respectively. The values reported are average values of the duplicate analyses. The mean and one standard deviation value is given for data in each table. Americium-241 activity levels obtained by gamma spectral analysis are listed in Table 5.

General Sediment Sampling Program

George H. Setlock and John D. Hurley

INTRODUCTION

Until 1973 when Plant site drainage patterns were altered, small quantities of radionuclides, principally plutonium-239, were released to the surrounding environs with liquid-process and sanitary wastewater discharges. The majority of the plutonium released through the surface waters has been retained in the sedimentary strata of holding ponds encircling the Plant's perimeter. A comprehensive discussion of the Rocky Flats Aquatic System (RFAS), i.e., surface and subsurface drainage, liquid-waste collection, and treatment and storage, is presented in the Rocky Flats Environmental Impact Statement (USDOE, 1980, Vols. 1 and 2).

During the past decade extensive studies have been undertaken to measure the amounts of plutonium in various compartments of the RFAS and to assess the movement and behavior of the radioisotope in the Plant's neighboring environment. These studies have been conducted by Plant personnel (Thompson, 1975; Cleveland and Rees, 1975; Rees et al., 1978; Hurley and Winsor, 1980; and Hurley, 1980 and 1981), the US DOE Environmental Measurements Laboratory (Krey and Hardy, 1970; Krey, 1976; and Hardy et al., 1978), by independent organizations such as Colorado State University (Johnson et al., 1974 and Whicker, 1974), and by the US Environmental Protection Agency (Lammering, 1975).

OBJECTIVES

The following is a summary of current objectives, methodology, and progress of the ongoing research program at Rocky Flats to examine radioactivity associated with sediments in water bodies adjacent to the Plant site.

1. Determine the depth distributions and radiological inventories of the plutonium, americium, uranium, and cesium in sediments of water bodies adjacent to the Rocky Flats Plant (i.e., Ponds A-1, A-2, A-3, B-1, B-2, B-3, B-4, C-1, Lindsay Pond, and the neighboring reservoirs shown in Figure 6).
2. Obtain transuranic distribution coefficients for each body of water and assess associated clean-up strategies for the Series A and B retention ponds.
3. Acquire a historical records of radionuclide distribution patterns of americium-241, cesium-137, lead-210, plutonium-238, plutonium-239, -240, and uranium-234 in the neighboring reservoirs and ascertain the fractions of plutonium in the sediments that resulted from global atmospheric fallout and from Rocky Flats Plant sources.
4. Identify key factors that regulate and affect transport of transuranic elements in sediment-water systems, and simultaneously characterize and model the migration of plutonium and americium in the RFAS using existing computer codes.

SAMPLING METHODS

Bottom sediment samples will be collected from the ponds and reservoirs near the Plant site using a Davis-Doyle piston corer and an Ekman grab sampler. The Davis-Doyle sampling apparatus* (Davis and Doyle, 1969) was specially designed to retrieve undisturbed bottom sediment cores. The collected samples will be 13.3 cm in diameter and either 91, 122, 152, or 183 cm long depending on the consistency of the sediment. The Ekman sampler is a bottom dredge of the grab type that is capable of recovering a superficial sediment layer of 3,540 cm^3. Approximately six sediment core and six grab samples will be collected from each body of water. All samples will be collected aboard the ES Branch's coring platform, the R/V ALBATROSS shown in Figure 7.

*Wildco Wildlife Supply Company, Saginaw, Michigan.

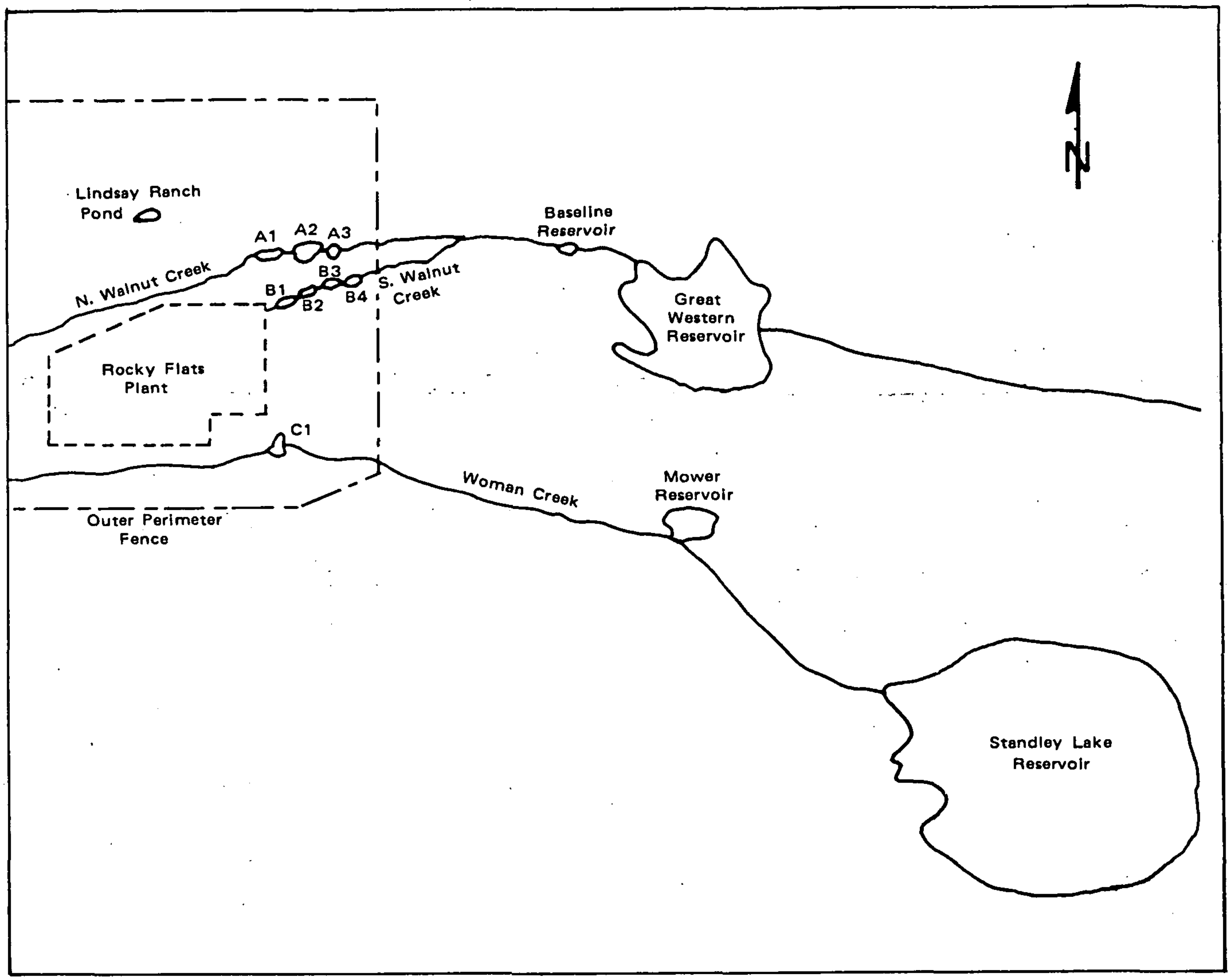

FIGURE 6. Study Area of the General Sediment Sampling Program Showing the Retention Ponds (Series A, B, and C), Lindsay Ranch Pond, and the Four Adjacent Reservoirs. Woman and Walnut Creeks flow to the east.

Sampling sites will be chosen on the basis of individual pond morphology and existing radiochemical data. The exact sites will be located using a surveyed grid network established for each pond or small reservoir. For the grid, a rectangular perimeter was surveyed for each body of water. One side of the perimeter corresponds to the dam or pond inlet boundary and the other three sides extend 10 m out from the high-water mark on each water boundary. For the larger bodies of water, an alternative surveying technique, using a laser ranging device, will be implemented.

In addition to sediment samples, soil and water samples will be collected. Analysis of these samples may permit identification of the principal mechanisms (e.g., runoff, direct discharge, and wet and dry deposition of airborne materials) that transport radionuclides to the sediment-water interface.

The water samples will be collected at three depths from one sampling site on each pond or reservoir: one surface grab sample, a sample from just above the floor of the water body, and one midway

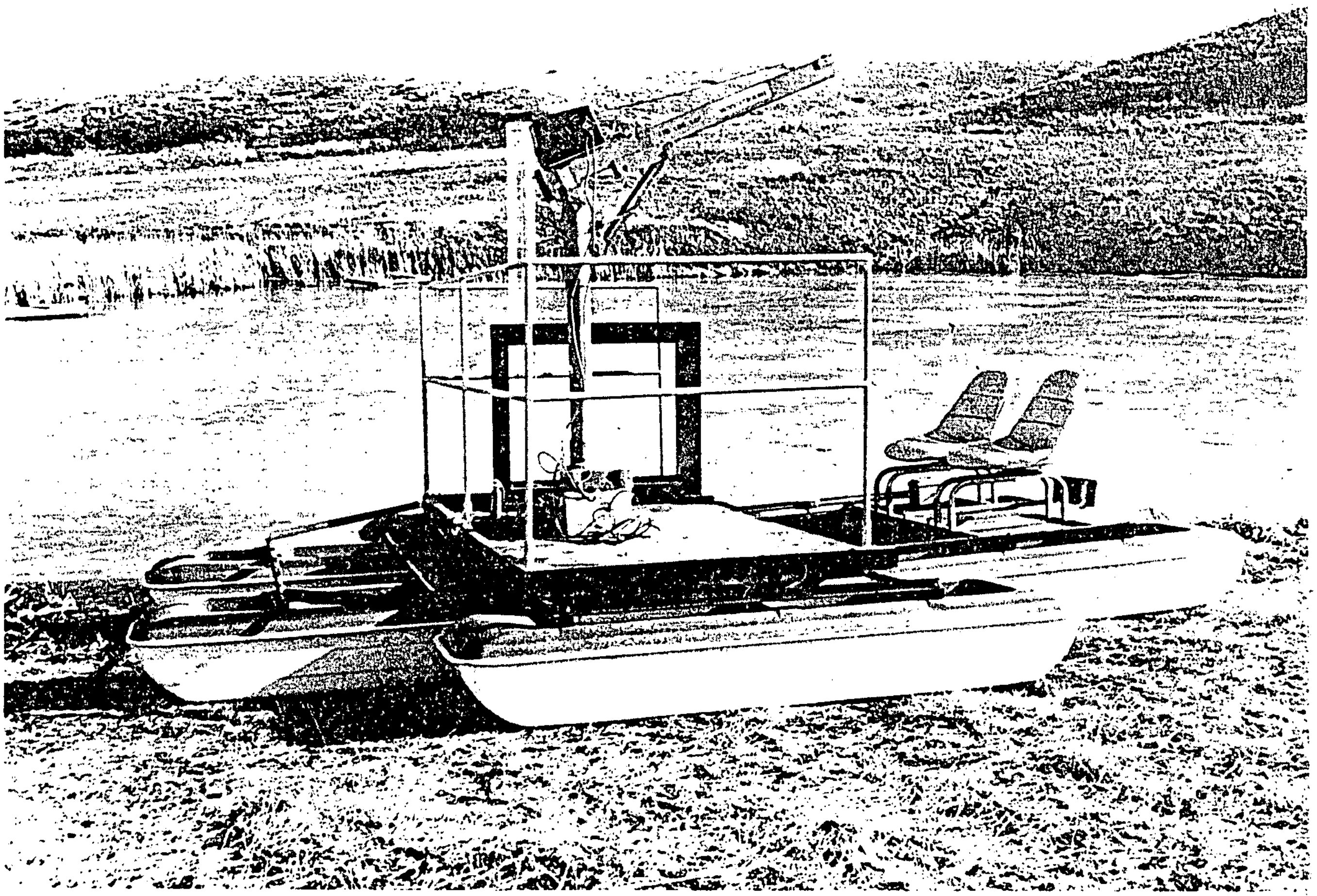

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FIGURE 7. Pontoon Craft Constructed for Sampling Water Bodies Adjacent to the Rocky Flats Plant Site. The R/V ALBATROSS is fitted with a stationary crane, electric winch and outboard and trolling motors to facilitate sediment collection with a specially designed Davis-Doyle coring apparatus.

between. Samples will be taken using a 2.2-ℓ Wildco Alpha-Style Kemmerer bottle.*

Four composite soil samples (one from each border) will be taken within the rectangular perimeter area of each water body. All soil samples will be collected according to Rocky Flats five-point sampling method using a 10 X 10 X 5-cm-deep sampling template. The composite samples will be made onsite by combining a central sample with samples taken at four cardinal points approximately 10 m apart (Illsley, 1979).

*Wildco Wildlife Supply Company, Saginaw, Michigan.

All sediment soil and water samples will be stored and prepared for chemical analysis as described in the 1979 Annual Report (Hunt and Hurley, 1981).

SAMPLE ANALYSES

Onsite Analyses

All samples collected in the study will undergo radiochemical analyses for americium-241, cesium-137, lead-210, plutonium-238, plutonium-239, -240, and uranium-234. Sediment and soil samples will be analyzed also for their particle size distributions, cation exchange capacities, organic matter contents (carbon, hydrogen, and nitrogen), and pH values. Water samples will be filtered through 0.22-μm Millipore filter paper to separate associated radionuclide materials into soluble and insoluble fractions. Standard water chemistry analyses (turbidity, pH, alkalinity, etc.) will be performed on all collected samples.

Offsite Analyses

Selected sediment cores possessing undisturbed stratigraphies (determined by X-ray radiography) will be radiometrically dated by cesium-137 and lead-210 content. The samples then will be shipped to an offsite laboratory for determination of the plutonium-239/plutonium-240 mass ratios. From the plutonium-239/plutonium-240 mass ratios in sequentially dated sediment layers, the global fallout mass ratio (0.18) and the mass ratio of Rocky Flats plutonium (0.06), i.e., the amounts and deposition times of Rocky Flats contributions to the plutonium present in the sediments, can be quantified.

SUPPLEMENTARY LABORATORY STUDIES

Supplementary laboratory studies will be undertaken to determine distribution coefficients for each water body and to assess the transfer of plutonium between water and sediments under a variety of physicochemical conditions. Previous Plant studies indicated that solubilization of plutonium-239, -240 and americium-241 by fulvic acid is slight (Cleveland and Rees, 1975), although enhanced dispersion of plutonium onto colloidal particles was found to be a significant process above pH = 9 (Rees et al., 1978). Studies by Cleveland and Rees will be verified and expanded using methods developed by the International Atomic Energy Agency's Marine Laboratory in Monaco. Additional details on sampling techniques, locations, storage and processing, radiochemical analyses, and laboratory studies are described in greater detail elsewhere (Hurley and Elgawhary, 1981).

PROGRESS

1. Perimeter grid surveys have been completed on the Series A and B ponds, Pond C-1, and Lindsay Ranch Pond.
2. The coring platform has been assembled and equipped to meet Colorado's licensing requirements as a Class A vessel.
3. Sediment sampling operations will commence following arrival of the piston corer, core liner kit, and stationary winch-crane needed to deploy the sampler.
4. Battelle–Pacific Northwest Laboratory, Richland, Washington, was found to have the mass spectroscopy facilities for conducting plutonium-239/plutonium-240 mass ratio analyses on the low-activity sediment samples.

TERRESTRIAL ECOLOGICAL STUDIES

General Ecology

Terrol F. Winsor

INTRODUCTION

Ecological studies of the vegetation on the Rocky Flats Plant site have shown that plant communities change considerably over periods ranging from weeks to years. By field analysis, it is possible to provide a description of floristic composition at test plots and measure similarity among the vegetation stands. If done once, such a description represents static aspects of plant communities. If repeated, the dynamic aspects of these communities may be made evident. To strengthen the understanding of short- and long-term fluctuations of plant communities, and the forces guiding these fluctuations, field work was continued during June 1980 on two onsite test

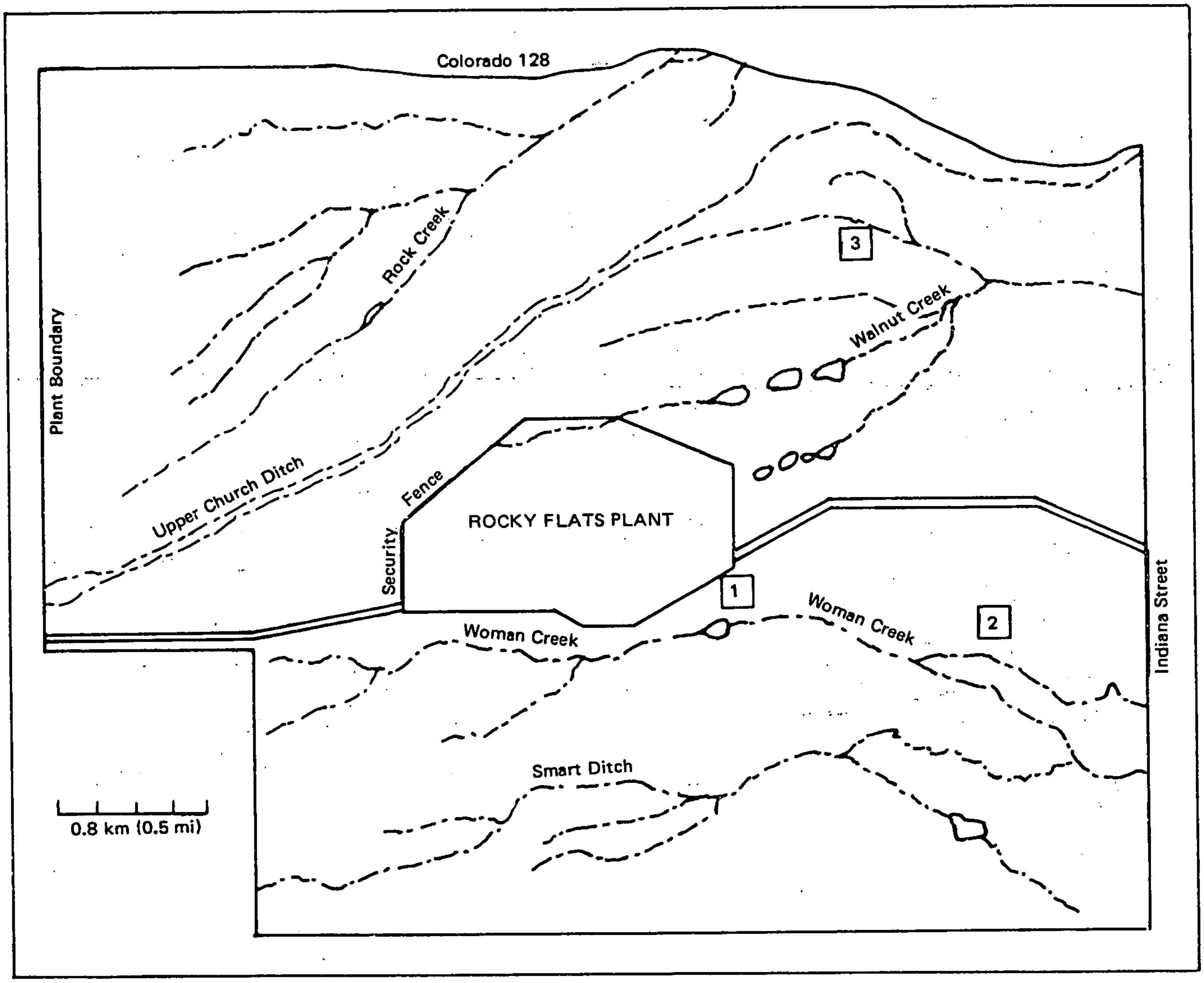


FIGURE 8. Rocky Flats Plant Site Including Buffer Zone and Three Ecological Study Plots

plots. The data presented here describe the vegetation structures of Plots 2 and 3 shown in Figure 8, and similarities can be drawn between the two plots. A view of community changes through time will be provided after more field data are collected.

METHODS

Vegetation community analysis was done in mid to late June. On each sampling plot, frequency and coverage of vegetation species, litter, exposed soil, and rock were obtained by use of a 20 cm X 50 cm metal quadrat frame placed at each of 121 sampling locations (Daubenmire, 1968). Data were subsequently evaluated by standard arithmetic techniques for comparisons among species and between plots.

RESULTS AND DISCUSSION

Analysis of vegetation data pertinent to Plots 2 and 3 are presented in Table 6. Absolute values of frequency and coverage of species are summed and used for calculation of relative frequency and

TABLE 6. Vegetation Data for Species in Plots 2 and 3

PLOT 2

Rank	Species[a]	Frequency	Relative[b] Frequency (%)	Coverage	Relative[b] Coverage (%)	Importance Value[c]
1	Bromus tectorum	0.90	13.38	0.2862	24.89	38.27
2	Agropyron smithii	0.66	9.82	0.2525	21.96	31.78
3	Bromus japonicus	0.84	12.52	0.1326	11.53	24.05
4	Buchloe dactyloides	0.37	5.52	0.1217	10.58	16.10
5	Lactuca serriola	0.68	10.06	0.0376	3.27	13.33
6	Bouteloua gracilis	0.38	5.64	0.0829	7.21	12.85
7	Tragopogon dubius	0.36	5.40	0.0322	2.80	8.20
8	Androsace occidentalis	0.38	5.65	0.0258	2.24	7.89
9	Sphaeralcea coccinea	0.30	4.42	0.0136	1.18	5.60
10	Camelina microcarpa	0.23	3.44	0.0186	1.62	5.06
Total of 10 species above		5.100	75.85	1.0037	87.28	163.13
Total of 39 total species		6.737	100	1.1500	100	200
Litter		1.00		0.8903		
Exposed soil		0.58		0.0965		
Rock		0.13		0.0064		

PLOT 3

Rank	Species[a]	Frequency	Relative[b] Frequency (%)	Coverage	Relative[b] Coverage (%)	Importance Value[c]
1	Bromus tectorum	0.62	10.12	0.3026	26.09	36.21
2	Agropyron smithii	0.84	13.76	0.2345	20.22	33.98
3	Bromus japonicus	0.84	13.63	0.2054	17.71	31.34
4	Lactuca serriola	0.78	12.68	0.0800	6.90	19.58
5	Stipa comata	0.20	3.23	0.0620	5.35	8.58
6	Collomia linearis	0.34	5.50	0.0248	2.14	7.64
7	Bouteloua gracilis	0.18	2.97	0.0285	2.46	5.43
8	Poa compressa	0.15	2.43	0.0343	2.96	5.39
9	Buchloe dactyloides	0.19	3.10	0.0262	2.26	5.36
10	Descurainia spp.	0.22	3.51	0.0145	1.25	4.76
Total of 10 species above		4.36	70.93	1.0128	87.34	158.27
Total of 50 total species		6.127	100	1.1597	100	200
Litter		1.00		0.9174		
Exposed soil		0.62		0.0802		
Rock		0.13		0.0033		

a. Only the 10 species ranking highest in importance value are listed.
b. For relative numbers, the combined totals of all species are set as 100 percent and numbers for individual species are taken as percents of the total.
c. Sum of relative frequency and relative coverage for a species.

relative coverage. Relative frequency and relative coverage values of a species are then summed to provide an importance value (I.V.) (Mueller-Dombois and Ellenberg, 1974). Only the 10 species ranking highest in importance value at each plot are listed in Table 6.

The results show that 10 of 39 species found in Plot 2 and 10 of 50 species found in Plot 3 accounted for about 80 percent of the total I.V. for each plot. In fact, about 50 percent of the total I.V. at each plot was represented by two annual grasses Bromus tectorum (Cheat-grass) and Bromus japonicus

TABLE 7. Frequency of Occurrence Data for Species Common to Plots 2 and 3

Species[a]	Plot 2, a_i	Plot 3, b_i	Common, c_i
Agropyron smithii	0.661	0.843	0.661
Allium textile	0.008	0.008	0.008
Androsace occidentalis	0.380	0.083	0.083
Artemisia frigida	0.099	0.083	0.083
Artemisia ludoviciana	0.091	0.058	0.058
Astragalus spp.	0.041	0.058	0.041
Bouteloua gracilis	0.380	0.182	0.182
Bromus japonicus	0.843	0.835	0.835
Bromus tectorum	0.901	0.620	0.620
Buchloe dactyloides	0.372	0.190	0.190
Camelina microcarpa	0.231	0.008	0.008
Carduus nutans	0.008	0.017	0.008
Carex spp.	0.050	0.041	0.041
Descurainia spp.	0.107	0.215	0.107
Erigeron spp.	0.248	0.008	0.008
Helianthus spp.	0.165	0.149	0.149
Lactuca serriola	0.678	0.777	0.678
Linum lewisii	0.008	0.008	0.008
Lomatium orientale	0.099	0.083	0.083
Lupinus argenteus	0.058	0.124	0.058
Opuntia compressa	0.033	0.025	0.025
Plantago patagonica	0.074	0.017	0.017
Poa canbyi	0.050	0.066	0.050
Poa compressa	0.058	0.149	0.058
Sitanion longifolium	0.091	0.025	0.025
Sphaeralcea coccinea	0.298	0.041	0.041
Tragopogon dubius	0.364	0.198	0.198
Vulpia octoflora	0.091	0.041	0.041
	a = 6.734[b]	b = 6.127[b]	c = 4.364

a. Species common to Plots 2 and 3 totaled 28, 11 additional species were unique to Plot 2 and 22 species were unique to Plot 3.

b. The a and b totals include frequencies for species unique to Plot 2 or Plot 3 but not listed above.

(Japanese Brome) and one perennial sod-forming grass Agropyron smithii (Western Wheat-grass). Previous discussions (Hunt and Hurley, 1981) of the significance of the most important species found on Plots 2 and 3 generally concluded that these plots are dominated by a mixture of species representative of the original grassland and weedy annuals common to disturbed ground. It is stressed that some species, especially annuals, will vary greatly in frequency and coverage depending upon season and rainfall trends. These annuals progress through their life cycle from seed germination to maturation and death in weeks. For example, Androsace occidentalis (Western rock-primrose) lives perhaps 3 weeks and is a very inconspicuous species (Weber, 1974). Perennial species, especially grasses, should be less subject to swift, wide fluctuations in the measured frequency and coverage values.

Frequency of occurrence data for the 28 species of vegetation common to Plots 2 and 3 are presented in Table 7. A coefficient of community (cc value) was calculated from these data according to Mueller-Dombois and Ellenberg (1974). The data in Table 7 yield a cc value of 67.9 percent. This number is an index only but is sufficiently high so that Plots 2 and 3 may be considered to contain plant communities of similar floristic composition. Because many of the important species common to Plots 2 and 3 are annuals, it is possible for the cc value to change considerably with season. It is felt that data are not yet sufficient to warrant comparisons with those data collected in 1978 and 1979.

FUTURE PLANS

Field analysis similar to the work reported here will continue. If possible, each of the three test plots will be sampled concurrently, twice per year, for examination of seasonal and yearly variation and for interplot comparisons. Also, collection of standing crop and litter will provide additional useful ecological measures. These data should be related to factors such as rainfall regime and disturbance if explanations of any structural changes are to be posed. When these data are consistently collected, at comparable times, during subsequent years, it should be valid to compare data from the same plot through time.

Radioecological Analysis

Terrol F. Winsor

INTRODUCTION

This section describes radioanalytical findings of vegetation collected on the Plant site during 1979 but not analyzed until 1980. The purpose of analyzing vegetation for plutonium-238, plutonium-239, -240, and americium-241 is to aid in evaluation of the environmental impact of Rocky Flats Plant (Hunt and Hurley, 1981). Data of the type discussed here may allow the calculation of a radionuclide inventory for Plots 2 and 3. Such inventories are to be considered valid for the sampling period and can be compared with similar data to be acquired during other seasons and later years. The comparisons will allow an evaluation of seasonal influence on radionuclide inventories of the vegetation and may provide observation of inventory changes over periods of years or decades.

METHODS

During September 1979 the estimated mass of standing vegetation was obtained by clipping all standing vegetation in a 1.0-m^2 frame centered on 10 of 42 sampling locations in each of Plots 2 and 3. Mass estimation of litter was obtained by collection of all litter at the same 10 locations. Vegetation samples were air-dried a minimum of two weeks before being weighed. Perennial grass samples collected in the same manner from Lafayette, Colorado, were used as controls. Selected samples were air-dried and weighed aliquots were submitted to Rocky Flats' Health, Safety and Environmental Laboratories for radioanalytical treatment. The HS&E Laboratories provided the reagent blanks.

RESULTS AND DISCUSSION

Vegetation samples were separated into three broad life-form categories: forbs, annual grasses, and perennial grasses. Statistical comparisons were not calculated because only two samples in each category were analyzed, and both sample results are listed in Table 8. The intent is to compare broadly the analytical results here and to make statistical comparisons when more vegetation samples are analyzed. Note that the highest radionuclide concentrations within each plot existed in the litter. This is not surprising because of the close association of litter with the soil surface. Soil is the environmental medium at Rocky Flats that typically contains the greatest radionuclide concentrations (Little, 1976). Forbs from Plot 2 contained higher concentrations of plutonium-239 and americium-241 than either annual grasses or perennial grasses. A proposed explanation is that concentration may be related to leaf surface area. Whereas this comparison is provocative, these data

TABLE 8. Radionuclide Concentrations of Vegetation From Plots 2 and 3

	Life Form[a]	Plutonium-238 (pCi/g ash)	Plutonium-239 (pCi/g ash)	Americium-241 (pCi/g ash)
Plot 2	Forbs	0.03	0.56	0.15
		0.04	0.37	0.14
	Annual Grass	< 0.04	0.11	0.04
		0.04	0.06	0.05
	Perennial Grass	< 0.02	< 0.02	< 0.05
		< 0.02	0.02	< 0.03
	Litter	0.14	5.09	1.79
		0.14	5.31	1.57
Plot 3	Forbs	< 0.03	< 0.02	0.16
		< 0.02	0.05	0.16
	Annual Grass	< 0.03	0.04	< 0.03
		< 0.03	0.04	< 0.04
	Perennial Grass	< 0.04	< 0.02	0.05
		< 0.03	0.03	< 0.02
	Litter	< 0.03	0.16	0.34
		0.03	0.31	0.15
Control	Perennial Grass	< 0.03	0.04	< 0.04
		< 0.03	0.04	0.03
	Reagent Blank	0.06	0.05	0.04

a. The reagent blank results have not been subtracted from the vegetation results.

are not directly comparable to earlier life-form data from Rocky Flats (Whicker, 1973 and Arthur, 1977), which resulted from vegetation samples treated differently and collected from an area of much higher plutonium levels. The goal here is to continue sampling in the described manner to determine whether a consistent difference in these radionuclide levels will be observed between life forms. The other life-form data listed in Table 8 do not show a clear trend, and in fact, the radionuclide levels are comparable to the control levels and the reagent blank.

The mass estimates of standing crop and litter in Plots 2 and 3 are presented in Table 9. The ash weights given in Table 8 were converted to air-dried weights by multiplying the ash weights by 30. The data from Table 8 and the mean concentrations from Table 9 can be combined and blank corrected to provide inventory estimates of radionuclide concentrations on Plots 2 and 3. Inventories can be calculated for life forms with radionuclide concentrations greater than zero; for example, plutonium-239 activity in forbs on Plot 2 was approximately 0.32 pCi/m^2. It is not possible to calculate inventories of some other radionuclides because their concentrations were not different from the reagent blank. Continued sampling will be used to verify or contradict these results.

The data reported here are a small portion of the information that eventually will provide an analysis of radionuclide distribution and perhaps transport

TABLE 9. Dry Weight of Standing Crop and Litter in Plots 2 and 3

Life Form	Plot 2 (g/m²) $\bar{X}$	S.D.	n[a]	Plot 3 (g/m²) $\bar{X}$	S.D.	n[a]
Forbs	23.2	16.2	10	38.1	32.7	10
Annual Grass	15.3	16.8	10	37.3	32.3	10
Perennial Grass	109.1	72.0	10	102.6	46.2	10
Unidentified Vegetation	35.1	11.5	9	46.2	24.9	10
Total Standing Crop[b]	179.2	80.7	10	224.1	73.9	10
Litter	132.3	24.4	10	177.0	31.6	10

a. Number of samples.
b. Because total standing crop was weighed before separation into the life forms, the parts do not precisely sum to weight of the total standing crop.

in Plots 2 and 3. Repeated sampling of vegetation, small mammals, and soil will be necessary to achieve the long-term goals of monitoring and modeling the influence of time on the terrestrial ecosystem compartmentalization of transuranics (Hunt and Hurley, 1981).

CRITICAL PATHWAY STUDIES

Betsy A. Briggs

INTRODUCTION

Transuranics released into the environment can take numerous pathways that eventually lead to man. Certain pathways are more important or critical than others. Two potential pathways are being examined on terrestrial Study Plot 1: direct consumption by man of (1) vegetation containing transuranics (principally americium and plutonium) either from root uptake or from airborne deposition and (2) grazing animals that have consumed vegetation containing transuranics. The data may be useful to calculate the transfer of americium and plutonium from soil to vegetation to cattle to man.

ROOT UPTAKE AND AIRBORNE DEPOSITION

Methods

A greenhouse was purchased and installed at terrestrial Study Plot 1 in Section Q shown on Figure 9. Food-crop plants will be grown in the Plot 1 soil, which contains known levels of plutonium and americium (Little, 1976). To separate the analysis of root uptake from external deposition, airborne particles are prevented from entering the structure by the following modifications made to the greenhouse:

- Installing a double door airlock
- Sealing the foundation and fiberglass seams
- Filtering the incoming air, cooled by a thermostatically controlled swamp mat pad cooler

An outside garden plot was placed near the greenhouse. Plants grown in this plot will give information on airborne deposition and root uptake of transuranics.

An outside garden plot placed at Lindsay Ranch will be used as a control because this area contains near background concentrations of plutonium in the soil. The Colorado Department of Health analyzed the local background level of plutonium in the top 0.3 cm of soil to be 0.036 pCi/g (USDOE, 1980).

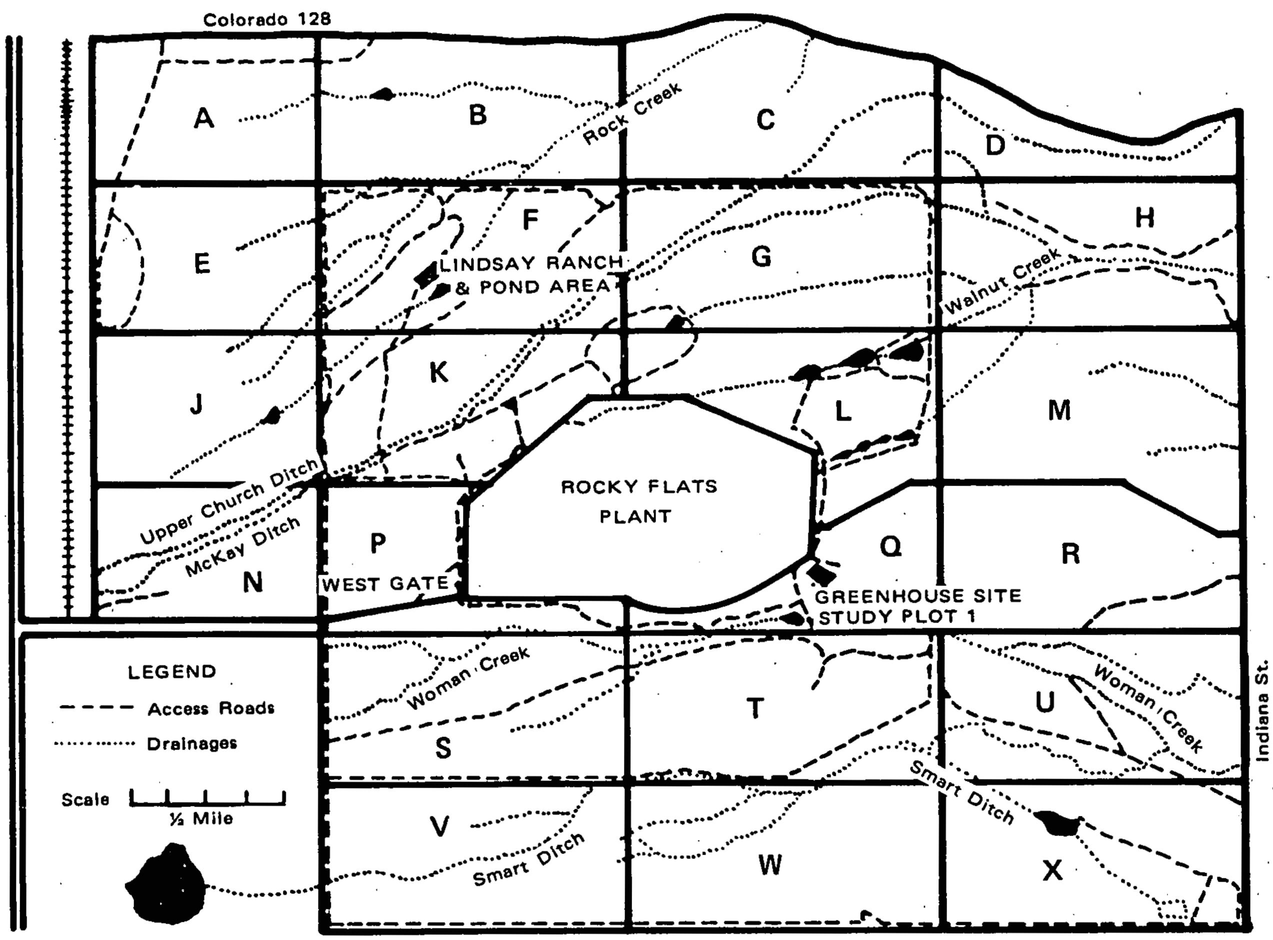


FIGURE 9. Garden Plots are Located at Study Plot 1 and at the Lindsay Ranch to Study the Uptake of Transuranics by Plants

Four-foot-high snow fences with chicken wire around the bases will protect both outside garden plots from animals.

Drip irrigation systems were installed for all three garden plots. Modified 55-gal barrels were placed uphill from the garden plot near the greenhouse for gravity feed to the irrigation system. Water from a tank placed uphill from the greenhouse is gravity fed to the irrigation system and the cooling system in the greenhouse. Water will be pumped up to the garden plot at Lindsay Ranch from Lindsay Pond using a submersible water pump powered by a generator.

Initial soil and standing vegetation samples were taken from the study plot and control areas. Two soil samples were taken from Lindsay Ranch and one sample was taken from the greenhouse plot and from the adjacent outside plot. The soils were sampled from vertical trenches at 5-cm increments to a depth of 25 cm. Duplicate vegetation samples were also taken from both areas. The soil and vegetation samples were analyzed for plutonium-238, plutonium-239, -240, and americium-241.

Standard vegetation and soil samples prepared by the Rocky Flats Standards Laboratory were analyzed along with the respective field samples.

TABLE 10. Alpha Spectral Analysis of Lindsay Ranch Soil Samples

Sample[a] Number	Soil Depth (cm)	Plutonium-238[b, c] (pCi/g)	Plutonium-239, -240[b, c] (pCi/g)	Americium-241[c] (pCi/g)
1	0–5	< 0.005	0.075 ± 0.007	< 0.085
2		0.008 ± 0.007	0.016 ± 0.005	< 0.086
1	5–10	0.004 ± 0.023	0.008 ± 0.004	< 0.083
2		0.013 ± 0.005	< 0.002	< 0.096
1	10–15	0.007 ± 0.007	0.004 ± 0.003	< 0.104
2		< 0.005	< 0.002	< 0.059
1	15–20	0.012 ± 0.011	< 0.002	< 0.094
2		< 0.005	< 0.002	< 0.102
1	20–25	< 0.005	< 0.002	< 0.094
2		< 0.005	< 0.002	< 0.117

a. Values for each of the duplicate samples are given.
b. Background level of plutonium in the top 0.3 cm of soil is 0.036 pCi/g.
c. The less than quantities are set to each sample's minimum detectable concentration level calculated from the sample's actual value divided by the recovery value.

TABLE 11. Alpha Spectral Analysis of Standing Vegetation Samples From Lindsay Ranch and the Greenhouse Sites[a]

Sampling Location	Plutonium-238 (pCi/g)	Plutonium-239, -240 (pCi/g)	Americium-241 (pCi/g)
Lindsay Ranch	< 0.058[b]	0.18 ± 0.064	< 0.148[b]
Greenhouse Site	1.10 ± 0.16	67.4 ± 4.72	< 16.1 ± 1.20

a. Average values of duplicate samples are given.
b. Minimum detectable concentration level.

The two standard soil samples prepared for plutonium-238 and plutonium-239, -240 had plutonium concentrations of 0.721 pCi/g and 572 pCi/g. The two soil standards for americium-241 had concentrations of 0.095 pCi/g and 132 pCi/g. The standard vegetation samples were prepared with plutonium concentrations of 0.099 pCi/g and 3.514 pCi/g, and the two americium-241 standards had concentrations of 0.050 pCi/g and 0.856 pCi/g.

Results

The Lindsay Ranch soil samples (Table 10) and the vegetation samples from both areas (Table 11) have been analyzed. The analytical values correlate well with the prepared standard values. The soil samples from the greenhouse site are currently being analyzed.

Near-Future Plans

The common, local backyard crops selected for cultivation are beets, carrots, green beans, lettuce, radishes, and spinach. The planting will be done in early July 1981. The seeds will be sown into small troughs and covered with straw to keep the soil moist and to prevent soil resuspension.

Water samples will be taken from Lindsay Ranch and the greenhouse water tank and will be analyzed for components that might enhance the solubility of plutonium and americium. A soil characteristics profile will be done on soil samples from both areas.

The efficiency of the intake air filter (Glasfoss G-2A) inside the greenhouse will also be determined. Rocky Flats' designed low-volume air sampler will be placed inside the greenhouse and each sample will be analyzed for total alpha activity and for concentrations of plutonium-238 and plutonium-239, -240.

When crops reach maturity, the leaves, roots, stems, and edible portions will be analyzed separately. The greenhouse vegetables will be washed in water as will half of the outside garden crops. All vegetable parts as well as the wash water will be analyzed for plutonium-238, plutonium-239, -240, and americium-241.

DEER TISSUE STUDY

Methods

The primary objective of this project is to determine the transport of transuranics to humans through the consumption of grazing animals exposed to transuranics in the soil and in the vegetation they consume. There are no cattle grazing on Plant site lands, but because the grazing habits of deer are similar to those of cattle, deer tissue analysis may be indicative of the highest levels of activity that might be found in cattle. Mule deer tissue samples will be collected whenever deer might be killed by motor vehicles on roads bordering the Rocky Flats Plant. Control samples will be collected from deer killed on roads some distance from the Plant site.

Lung, cannon-leg bone, liver, and hindleg muscle samples have been collected from five road-killed deer on or near the Rocky Flats Plant site. The samples have been frozen until ashing and analysis can begin.

A muffle furnace was purchased to ash the samples. The furnace and trays have been cured to 1000 °F by increasing the temperature at 100 °F increments for 60-min soak periods at each increment. Control samples were obtained from Dr. A. William Alldredge in the Department of Radiology and Radiation Biology at Colorado State University. Richard Lopez with the Colorado Division of Wild-Life, Law Enforcement Division, has also agreed to collect control samples.

Near-Future Plans

Ashing and analysis of the samples will begin once a sheet metal shroud is constructed over the muffle furnace. The samples will be analyzed for plutonium-238, plutonium-239, -240, and americium-241.

LAND MANAGEMENT

Land Management Policy and Its Implementation

Terrol F. Winsor

INTRODUCTION

Between January and June 1980, no changes were made in the general policies developed by Rockwell International for management of all Plant site open space land. The Rocky Flats Land Management Policy and Plan are guidelines for implementing environmental and physical controls to minimize adverse environmental impacts resulting from varied uses of the Plant land.

LAND USE REQUESTS

During this reporting period 16 Land Use Requests were received, and each met the factor requirements of one of the permitted land use categories described in the 1978 Annual Report (Hunt and Hurley, 1980). Only four of the requests listed in Table 12 originated from offsite users, two of which were associated with a Department of Energy contract for geologic and seismic studies. Jefferson County Public Schools requested to continue environmental field studies on the Plant site, and a Broomfield resident requested to observe the stone circles believed to be of Native American construction in the northern buffer zone for purpose of mention in a history of Broomfield. Most requests by onsite users were concerned with sampling for research or monitoring purposes. The land use request that will result in greatest environmental impact will be the construction of a new Wind

TABLE 12. Tabulation of Land Use Requests Initiated or Acted Upon During January–June 1980

User	Description	Action
Plant Utilities	Sprinkle sewer effluent water from B-3 Pond and 207B South Pond in Sectors L, M, Q, and R of buffer zone and Areas 100 and 900 within security fence	Approved directly by LMC chairman
Environmental Analysis	Weed control in buffer zone by aerial spraying of Banvel "D" and 2,4-D	Approved directly by LMC chairman
Environmental Studies	Plant vegetable gardens at two buffer zone sites to study root uptake and airborne deposition of radionuclides	Approved after referral to LMC
Environmental Analysis	Cut, bale, and remove hay from Sectors U and X of buffer zone	Approved after referral to LMC
Microgeophysics Corporation	Monitor seismicity in and around Rocky Flats Plant	Approved directly by LMC chairman
Environmental Studies	Collect data on soil resuspension in area east of asphalt pad	Approved after referral to LMC
Environmental Studies	Operate ultrahigh-volume air sampler in area east of asphalt pad	Approved directly by LMC chairman
Jefferson County Schools	Environmental field studies of Sector C of buffer zone by about 610 students	Approved directly by LMC chairman
Wind Systems	Construction of Wind Energy Systems Test Center	Approved after referral to LMC Executive Committee
Environmental Analysis	Ambient air quality monitoring	Approved directly by LMC chairman
Environmental Studies	Collect environmental samples from buffer zone for ecological field studies	Approved directly by LMC chairman
Dames and Moore Corporation	Conduct field geologic mapping and investigation of seismic refraction lines in buffer zone	Approved directly by LMC chairman
Jo Ann Ellerbrock of Broomfield	Observe stone circles in Sectors B and F of buffer zone for writing of history of Broomfield	Approved directly by LMC chairman
Environmental Studies	Soil sampling for radionuclide analyses in Sectors R, U, and G of buffer zone	Approved directly by LMC chairman
Environmental Analysis	Soil sampling for radionuclide analyses in Sectors R and U of buffer zone	Approved directly by LMC chairman
Environmental Studies	Install high-volume air samplers along east security fence	Approved directly by LMC chairman

Energy Systems Test Center. The Test Center proposal was reviewed and approved by the Land Management Council Executive Committee.

One noteworthy buffer-zone project was concluded, and the project area was satisfactorily cleared of equipment. This was a doctoral research project by L. Brown of the Department of Environmental, Population, and Organismic Biology of the University of Colorado. Ms. Brown subsequently provided Rocky Flats with a thesis copy entitled "Demography, Distribution, and Seasonal Adaptations of Small Mammals in a Colorado Piedmont Grassland."

When evaluating a Land Use Request, the Land Management Council considers the amount of vegetation disturbance or destruction that may result from conducting the proposed project. All project sites must be satisfactorily decommissioned and cleaned following completion of the project, and if damaged, the site must be restored. The Land Management Program is continuing evaluation of the revegetation practices used at the Plant. Several years of observation of restored sites is necessary to determine the efficacy of the practices.

Remote Sensing Program

Terrol F. Winsor

INTRODUCTION

The Rockwell International and Department of Energy commitment to care for all Rocky Flats Plant lands is met, in part, by continued assessment of land management practices and by evaluation of the effects of Plant operations on the ecological status of the land. Remote sensing techniques are used to aid in satisfying this commitment. The potential benefits of remote sensing were summarized in the 1978 Environmental Studies Annual Report (Hunt and Hurley, 1980), wherein it was also indicated that a yearly record would be most useful. Consistent with this objective, color and color infrared aerial photographs of the Rocky Flats Plant site were obtained in the years 1978 and 1979.

AERIAL PHOTOGRAPHY

The 1978 and 1979 aerial photography sessions were described in the 1979 Annual Report (Hunt and Hurley, 1981). During 1979 funding was unavailable for technical analysis of the photographs, but the photographs were used for a variety of purposes that resulted in savings in personnel time and effort during the first half of CY 1980. They were used (1) as visual aids during seminars or in technical reports by both Plant and offsite personnel, (2) in litigation work, (3) for evaluation of the effects on Plant site vegetation of construction associated with the Surface Water Runoff Control Project, and (4) for qualitative evaluations of vegetation vigor for specialized ecological purposes. The photographs provide a permanent record of land status at a particular time and may be analyzed in detail at anytime when funds, equipment, and expertise become available.

During the first half of CY 1980, we continued communications with EG&G Energy Measurements Group of Las Vegas, Nevada, to schedule aerial photography of Rocky Flats Plant for the latter half of CY 1980. The results of this effort will be conveyed in the next semi-annual report.

POPULATION HEALTH EFFECTS

Robert W. Bistline

The 1979 Environmental Studies Group Annual Report (Hunt and Hurley, 1981) discusses the difficulties of tracking and assessing epidemiological health effect studies impacting the Rocky Flats

Plant and the Plant's surrounding communities. In the first half of CY 1980, a revised three-year proposal, "Monitoring and Review of Epidemiological Studies of Denver Populations," was submitted to the Department of Energy for approval and funding at $87,000 per annum. If approved, the proposal will provide for a consultant group of credible and internationally recognized people in the field of epidemiology and bio-statistics to review and respond to papers or reports from Denver area population studies that impact the Rocky Flats Plant.

In support of the proposal, several meetings were held with the Epidemiology Department of the Colorado State Health Department. The State Health Department has agreed to furnish Rocky Flats with data from the Colorado Cancer Registry for 1976 through 1979 and also with 1980 census data for the Denver region.

QUALITY ASSURANCE PROGRAM

Environmental Analysis Quality Program Plan

Daryl D. Hornbacher and Irene M. Meisel

INTRODUCTION

Rockwell International has implemented a policy to maintain an effective quality assurance program. The program at Rocky Flats Plant assures a requisite level of quality throughout all areas of contract performance and also ensures that quality will not be compromised in relation to costs or schedules.

ORGANIZATION AND RESPONSIBILITIES

The scope, responsibilities, and references for the Process and Product Quality Control Policy are described in the Rocky Flats Plant Policy Manual. The Rocky Flats Quality Program Manual and supplementary Quality Program Plans document the plant wide responsibilities and organizational authorities for program implementation by management. Customer quality requirements and the general methods for accomplishing them are also referenced in the Quality Program Manual and Plans. Specific responsibilities, detailed procedures, diagrams and forms are included in the discussions of the operating procedures. The Quality Program applies to all activities at Rocky Flats and is designed to provide compliance with the requirements of governmental agencies, other customers, and Rockwell International, as applicable. Administrative controls are established and maintained, and results of inspections, tests, and evaluations are recorded and analyzed for the prevention, detection, and correction of deficiencies. Meaningful summaries are reported in a timely manner to the appropriate department for corrective action. All facets of the Quality Program are subject to periodic audits.

The Quality Program "Elements" include the Health, Safety and Environment (HS&E) Department, which has the overall responsibility for (1) developing policies and requirements to promote a safe and healthful working situation for Rocky Flats employees, (2) protecting the environment and the public in relation to Plant activities, and (3) monitoring environmental data to assure the maintenance of a healthful environment.

PLAN DEVELOPMENT

The Quality Program Plan developed for the HS&E Environmental Analysis (EA) Group was completed and approved during this reporting period. The EA Group is responsible for (1) developing and maintaining programs for environmental monitoring and control, (2) monitoring meteorological data, (3) conducting surveillance of Plant operations and (4) establishing emergency and fallout response programs.

During the spring of 1980, the EA Group began implementation of the Quality Program Plan that

TABLE 13. Environmental Analysis Group Activities and Responsibilities[a]

Activities	Responsible Individual or Organization
Environmental Monitoring	
Maintain an up-to-date environmental monitoring program.	EA Manager
Preparation, approval, and update of procedures for sample collection.	EA Manager and Specialists
Preparation, approval, and update of sampling plans.	EA Manager and Specialists
Preparation, approval, and update of analysis schedules.	EA, HS&EL, 881 Laboratories
Development and coordination of new techniques for environmental monitoring through special study programs.	EA, HS&EL, Environmental Studies
Develop and implement action levels for control of nonradioactive and radioactive effluents in air and water discharges.	EA Manager and Specialists
Document and maintain historical records of environmental monitoring data and environmentally related actions.	EA Manager
Maintain computer programs for analysis of environmental monitoring data.	EA Specialist
Evaluate, interpret, and report environmental monitoring data to the appropriate governmental agency.	
Preparation of monthly environmental monitoring report for presentation at State Information Exchange Meeting.	EA Specialists, HS&EL, 881 Laboratories
Preparation of Annual Environmental Monitoring Report.	EA Specialists, HS&EL, 881 Laboratories
Preparation of NPDES Permit Quarterly Report.	EA Specialist
Nonconformance reporting.	EA Manager
Develop schedules for calibration of environmental monitoring equipment.	EA Specialists
Calibrate environmental monitoring equipment.	Standards Laboratory
In-field maintenance of monitoring equipment.	EA, and Maintenance
Meteorological Monitoring	
Preparation, update, and approval of meteorological monitoring plan.	EA Manager and Specialist
Determine criteria for monitoring equipment and provide for acquisition of necessary equipment.	EA Specialist

(Continued)

is designed to meet the objectives of the overall Plant Quality Program. The Program Plan requires that

- Current operating procedures are prepared for all phases of EA Group operations and that these procedures are implemented as written.
- Appropriate approvals are obtained before program initiation or change.
- Equipment used in sample collection and data analysis is appropriate to the assigned function and is operating as required.
- Accurate documentation is made of all quality programs, procedures, and actions.
- All variances from specified procedures or equipment use and performance are documented and explained with an impact assessment.
- Appropriate guidelines and standards for environmental monitoring are identified and compliance is documented on a routine basis to Rockwell and Department of Energy management and to state and federal regulatory agencies.

Activities and responsibilities of the EA Group also are outlined in the Plan. The Environmental Monitoring Program is designed to (1) evaluate and limit the overall impact of Plant operations on the surrounding environment and (2) ensure compliance

TABLE 13. Environmental Analysis Group Activities and Responsibilities[a] (Concluded)

Activities	Responsible Individual or Organization
Generate and maintain a continuous historical meteorological record.	EA Specialist
Manage calibration and maintenance of meteorological monitoring equipment.	EA Specialist
Calibrate and maintain monitoring equipment.	Standards Laboratory, Radiation Instrumentation
<u>Plant Operation Review and Surveillance</u>	
Review, approve, and/or make environmental recommendations for construction and engineering authorizations, proposals, and applications and for operational safety analysis.	EA Manager and Specialists
Review and control of nonroutine solid waste disposal.	EA Manager and Specialists
Monitor and approve water discharges from holding ponds.	EA Manager and Specialists
Design environmental monitoring plan to provide surveillance during construction and soil removal and monitor for compliance with plan.	EA Manager and Specialists
Manage plantwide radiometric survey.	EA Specialist
Manage and audit land use activities following approval of land use request.	EA Specialist
Manage erosion control and weed control activities and land restoration following soil removal or construction activities.	EA Specialist
<u>Emergency and Fallout Response</u>	
Develop and maintain emergency response plans to control and minimize environmental insult and monitor and assess environmental impact.	EA Manager and Specialist
Utilize environmental monitoring, meteorological monitoring, and ARAC to evaluate environmental release.	EA Manager and Specialist
Develop and maintain a fallout response procedure to monitor and report the periodic increase in fallout resulting from atmospheric nuclear weapons testing.	EA Manager and Specialist
Manage calibration and maintenance of emergency environmental monitoring equipment.	EA Specialists
Calibrate and maintain emergency environmental monitoring equipment.	Standards Laboratory, Radiation Monitoring, and Maintenance

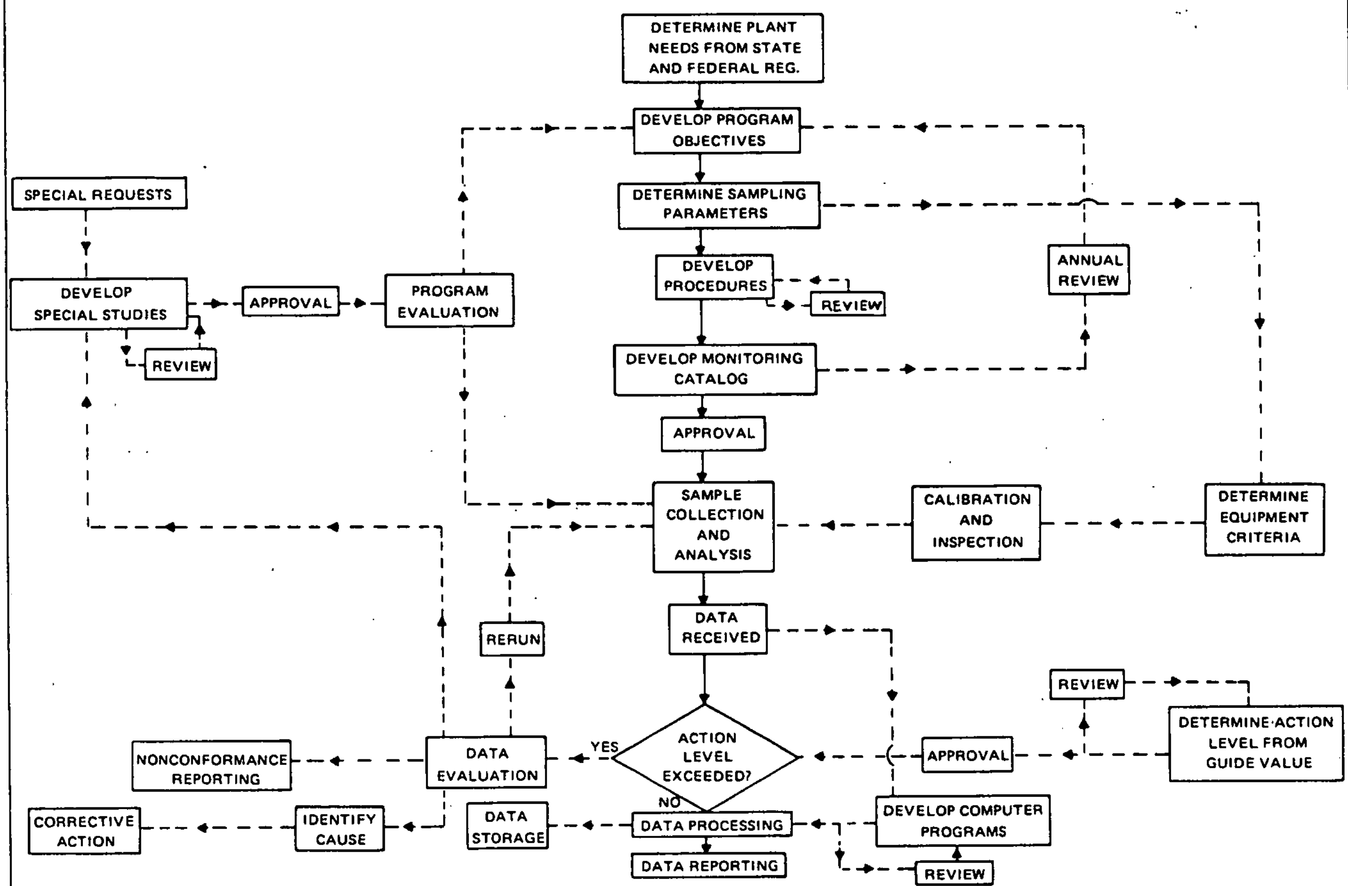
a. This table is not subject to update in case of revision of original document.

with applicable guidelines for radioactive and nonradioactive discharges to the environment. Compliance is assessed by monitoring of stack effluents, ambient air, water, soil, and water-body sediments. The Meteorological Monitoring Program provides meteorological data specific to the Rocky Flats Plant site that are useful in determining site wind profiles during routine and emergency conditions. The Plant Operation Review and Surveillance Program includes all activities required to (1) establish, review, and update environmental criteria for control of pertinent Plant operations and activities and (2) monitor for compliance with the Program. The Emergency and Fallout Response Programs outline the procedures to be carried out (1) during emergency situations and (2) upon notification of a fallout alert for monitoring environmental radioactivity. A more complete listing of activities and responsibilities is presented in Table 13.*

Quality Assurance Flow Charts and Matrices are prepared for each of the four major functions of the EA Group. Each flow chart illustrates the activity network for a specific area of responsibility. Quality Matrices define quality elements associated with the activities of that area. A flow chart and a

*This table was taken from the Rocky Flats Health, Safety and Environment Quality Program Manual (1977).

TABLE 14. Flow Chart for Environmental Monitoring[a]



a. This flow chart is not subject to update in case of revision of original document.

corresponding matrix prepared for the environmental Monitoring Program are shown in Tables 14* and 15,* respectively.

The completed Quality Program Plan for the Environmental Analysis Group

- Provides visible, documented evidence of Rockwell's intent to comply with the Department of Energy and with state and federal regulations.
- Provides required protection to the public and the environment.
- Establishes control points and delineates responsibilities in all secured areas.

*These tables were taken from the Rocky Flats Health, Safety and Environment Quality Program Manual (1977).

- Provides an information base from which procedures can be developed.
- Establishes a state-of-emergency preparedness in its contingency plans by recognizing potential adverse conditions in advance.

PLAN IMPLEMENTATION

Implementation of the EA Groups Quality Program Plan will be an ongoing activity. Current activities include (1) updating procedures and developing new ones, (2) calibrating environmental monitoring instruments, (3) defining error-terms associated with

TABLE 15. Quality Matrix: Environmental Monitoring[a]

QUALITY ELEMENTS / ACTIVITIES	SAMPLING PLANS	SAMPLE COLLECTION	ANALYSIS SCHEDULES	EFFLUENT IDENTIFICATION AND CONTROL	SPECIAL STUDIES	EQUIPMENT ACQUISITION AND MAINTENANCE	COMPUTER PROGRAMMING, VERIFICATION, AND UTILIZATION	DATA EVALUATION	DATA REPORTING	HISTORICAL DATA MAINTENANCE
DOCUMENT REVIEW AND APPROVAL	X	X	X	X	X	X	X	X	X	X
DOCUMENT RELEASE AND CHANGE CONTROL	X	X	X	X	X	X	X	X	X	X
PROCUREMENT CONTROL		X				X	X			
MEASUREMENT AND TEST EQUIPMENT CALIBRATION AND CONTROL		X		X	X	X				
TESTING AND EVALUATION	X	X		X		X	X			
INSPECTION		X		X		X				
DATA DOCUMENTATION AND CONTROL				X	X			X		
CERTIFICATION		X				X				
RECORDS COLLECTION, STORAGE, AND MAINTENANCE		X			X					X
OPERATIONAL CONTROL	X	X						X		
PROBLEM, FAILURE, AND NONCONFORMANCE REPORTING AND ANALYSIS		X		X		X		X		
CORRECTIVE ACTION CONTROL		X		X		X		X		
AUDIT PLANNING, PERFORMANCE, AND REPORTING				X						
RADIATION MONITORING		X		X						
STANDARDS COMPLIANCE		X		X						

a. This matrix is not subject to update in case of revision of original document.

data derived from the Environmental Monitoring Program, (4) developing computer and statistical support capabilities, and (5) enhancing the control aspects of the Quality Program Plan.

Calibration of Rocky Flats Ambient Air Samplers

Carol J. Barker and R. Larry Thompson

INTRODUCTION

The 49 Rocky Flats designed high-volume ambient air samplers used in the routine Environmental Monitoring Program are described in detail in Rockwell Engineering Drawings 27261-1 through 27261-6. These samplers are located on the Rocky Flats Plant site, at the Plant perimeter, and in 12 surrounding communities. They operate continuously at a volume flow rate of approximately 15 ℓ/s (32 cfm). To comply with the Environmental Analysis Quality Program Plan, a routine Calibration and Certification Program for these samplers was requested from the Physical Metrology Laboratory (PML) of the Rocky Flats Standards Laboratory.

AIR SAMPLER SURVEY PLAN

Before establishing a routine Calibration and Certification Program, PML personnel designed an air sampler survey plan (Thompson, 1980) to establish airflow specifications for assigning volume measurement accuracy at the 95% confidence level. The accuracy level corresponding to this confidence level was then chosen as the acceptable calibration certification group tolerance.

The criteria defined at the beginning of the Survey Plan were the following.

1. Control

   Daily reviews will be made of collected data by the PML engineer in charge.

2. Survey Interval

   A time span of at least eight weeks during which a minimum 50 °F temperature variation occurred between the warmest and coldest survey days will be used.

3. Planned Grouping

   Each sampler will be surveyed at least once per week to ensure the data are representative of the entire sampler population.

4. Randomization

   Data will be collected in a similar manner from all samplers under diverse conditions, approximately an equal number of times per sampler.

5. Replication

   A sample will consist of about 750 measurements to estimate the standard deviation within 5% of its true value with a confidence coefficient equal to 0.95 (Natrella, 1966). An arbitrary factor of 4 was chosen to account for lack of total independence between measurements. This choice of multiplier required approximately 3000 flow measurements.

RESULTS OF SURVEY PLAN

The Air Sampler Survey Plan was initiated during February 1980. By August 1980, all Rocky Flats Plant routine high-volume ambient air samplers will be calibrated, certified, and assigned to a routine 3-month interval recalibration and certification program. The data collected during the air sampler survey will be statistically evaluated for the purpose of assignment of volume measurement error-terms to ambient air data. This statistical evaluation will be completed by December 1980.

MONITORING DATA EVALUATION

Correlation Between Biochemical Oxygen Demand and Total Organic Carbon

Ronald L. Henry

INTRODUCTION

The domestic wastewater generated at the Rocky Flats Plant contains a large amount of organic material. This sanitary wastewater is treated in the Sewage Treatment Plant with the principal objective of removing as much of the organic material as possible. By removing the organic materials from the water, an oxygen demand is not placed on downstream receiving water.

MEASUREMENTS OF ORGANIC MATERIAL

To measure how effectively the Sewage Treatment Plant removes these organic materials, two types of measurements are used: (1) one that indicates some fraction of the total organic matter by measuring the biochemical oxygen demand (BOD-5) and (2) one that expresses the total amount of organic matter by determining the total organic carbon (TOC).

The BOD-5 determination (conducted every 5th day) is a relatively tedious empirical test. Standardized laboratory procedures are used to determine the oxygen demand in the wastewater produced by carbonaceous and nitrogenous compounds and by immediate oxidation.

The TOC measurement is easier and faster to perform. It conveniently estimates the degree of organic contamination if an empirical relationship has been established with a BOD-5 determination.

RESULTS

BOD-5 determinations and their corresponding TOC measurements for wastewater effluents from Rocky Flats' NPDES* discharge location 001 are presented in Tables 16 and 17 for 1979 and 1980, respectively. Beginning in mid-December 1979 all sanitary wastewater effluent from discharge location 001

*National Pollutant Discharge Elimination System.

TABLE 16. Rocky Flats NPDES Discharge Location 001 Biochemical Oxygen Demand and Total Organic Carbon Concentrations (mg/ℓ) for 1979

January			February			March			April			May			June		
Date	BOD_5	TOC	Date	BOD_5	TOC	Date	BOD_5	TOC	Date	BOD_5	TOC	Date	BOD_5	TOC	Date	BOD_5	TOC
3	10	7	1	4	18	1	< 1	16	4	4	18	2	7	16	1	2	16
4	3	9	2	< 1	20	2	3	17	11	3	19	3	8	16	6	2	17
5	3	9	7	2	10	7	7	17	12	5	20	4	4	17	7	< 1	17
10	4	7	8	2	16	8	11	18	18	8	19	9	4	15	8	1	19
11	2	6	9	4	16	9	< 1	19	19	< 1	18	10	< 1	19	13	2	16
12	4	16	14	3	19	16	8	18	20	3	18	11	4	18	14	3	20
17	2	15	15	< 1	18	28	4	16	25	5	16	16	4	10	15	2	22
18	2	15	16	19	26	29	2	25	26	1	15	17	4	12	20	2	20
19	2	20	21	3	20	30	4	29	27	< 1	19	18	7	15	21	4	21
24	4	14	22	6	21							23	< 1	21	22	5	17
25	7	17	23	3	20							24	4	18	27	< 1	19
26	4	15	28	< 1	14							25	2	16	28	6	16
31	6	14													29	2	16

(Continued)

TABLE 16. Rocky Flats NPDES Discharge Location 001 Biochemical Oxygen Demand and Total Organic Carbon Concentrations (mg/ℓ) for 1979 (concluded)

July			August			September			October			November			December		
Date	BOD_5	TOC	Date	BOD_5	TOC	Date	BOD_5	TOC	Date	BOD_5	TOC	Date	BOD_5	TOC	Date	BOD_5	TOC
3	2	17	1	< 1	14	5	1	19	3	2	22	1	< 1	23	5	12	26
5	3	18	2	6	14	6	< 1	17	4	5	21	2	7	23	6	< 1	25
6	4	16	3	4	20	7	< 1	17	5	5	21	7	9	19	7	22	24
11	3	18	8	< 1	11	12	< 1	14	10	11	18	8	2	20	12	< 1	19
12	4	12	9	2	13	13	2	19	11	9	23	9	< 1	19	13	10	19
13	5	11	10	6	19	14	< 1	19	12	10	20	14	4	16	14	< 1	19
18	2	19	15	1	18	19	< 1	17	17	< 1	21	28	12	20	19	4	20
19	2	15	16	< 1	23	20	< 1	15	18	11	25	29	< 1	23	20	15	21
20	< 1	17	17	< 1	22	21	< 1	15	19	14	26	30	1	23			
25	5	15	22	< 1	17	26	17	20	24	4	13						
26	8	17	23	2	19	27	4	22	25	1	17						
27	< 1	17	24	2	17	28	4	20	26	8	18						
			29	2	21				31	4	22						
			30	< 1	19												
			31	8	18												

TABLE 17. Rocky Flats NPDES Discharge Location 001 Biochemical Oxygen Demand and Total Organic Carbon Concentrations (mg/ℓ) for 1980

January			February			March			April			May			June		
Date	BOD_5	TOC	Date	BOD_5	TOC	Date	BOD_5	TOC	Date	BOD_5	TOC	Date	BOD_5	TOC	Date	BOD_5	TOC
2	< 1	15	1	7	22	5	3	23	3	3	21	1	12	23	4	13	29
3	21	15	15	8	22	6	4	27	10	10	29	2	14	22	5	7	25
4	5	17	20	8	30	7	1	23	16	5	26	7	8	35	6	12	28
9	8	22	21	11	32	12	< 1	25	17	11	26	8	3	25	13	16	30
10	4	22	22	21	26	13	1	20	18	7	26	9	4	29	18	6	24
11	5	23	27	< 1	24	14	12	31	23	11	29	14	8	33	19	3	28
16	2	20	28	6	25	21	16	23	24	4	12	15	7	28	20	21	34
17	2	22	29	2	24				25	11	24	16	7	31	25	23	28
18	9	24							30	6	27	21	2	30	26	2	26
30	11	24										22	13	32	27	7	28
31	4	27										23	36	30			
												28	10	20			
												29	23	23			
												30	8	21			

has been used for onsite irrigation and/or for make-up water for the Reverse Osmosis Facility.

The correlations between BOD-5 and TOC measurements were determined from a linear-regression analysis. The results are shown in Table 18. A correlation coefficient of ±1.00 is perfect.

For the 1979 BOD-5 and TOC data, the overall correlation is poor, with an average value of +0.23.

TABLE 18. Correlation Coefficients From Biochemical Oxygen Demand and Total Organic Carbon Determinations

1979	Coefficients	1980	Coefficients
January	-0.17	January	-0.24
February	+0.68	February	+0.32
March	-0.16	March	+0.39
April	+0.30	April	+0.60
May	-0.37	May	-0.08
June	-0.13	June	+0.67
July	-0.34	–	–
August	-0.03	–	–
September	+0.45	–	–
October	+0.42	–	–
November	-0.26	–	–
December	+0.38	–	–
Overall	+0.23	Overall	+0.56
Number of Determinations	137	Number of Determinations	59

TABLE 19. Trend-Line Analysis of 1980 Total Organic Carbon Data

If BOD_5 Is (mg/ℓ)	Expected TOC (mg/ℓ)
1	0
3	21.8
5	22.0
7	22.3
10	22.7
13	23.1
15	23.3
17	23.6
20	24.0
22	24.2
25	24.6
67	30.0

The 1980 data shows a much better correlation with an average value of +0.56. Generally, both BOD-5 and TOC data are higher for 1980 than for 1979. Environmental Protection Agency personnel stated in a personal communication on April 10, 1979 that better correlations between BOD-5 and TOC data are observed at higher measurement values.

A trend-line analysis was performed on the 59 TOC determinations from 1980 to predict TOC results from given BOD-5 determinations. The results are listed in Table 19. Based on the limited amount of data, it appears that above 25 mg/ℓ, the BOD-5 determination is not a good predictor of TOC measurements.

PUBLICATIONS AND PRESENTATIONS

Reports of research projects performed by the Environmental Sciences Branch are often accepted for publication in technical and abstracting journals and for presentation at technical meetings. The following is a list of publications and presentations made between January and July 1980. Several of the reports presented as talks during the first half of CY 1980 were originally published in the Environmental Studies Group Annual Report for CY 1978.

Presentations

1. *Determining Total Tritium Content of Rocky Flats Stack Emissions,* J. D. Hurley, excerpted from Rocky Flats Plant report RFP-2866 in Conf. Proc. on Tritium Technology in Fission, Fusion and Isotopic Application, American Nuclear Society National Topical Meeting, April 29–May 1, 1980, Dayton, Ohio.
2. *Plutonium/Americium Inventory of the Smart Ditch Pond Ecosystem,* J. D. Hurley and T. F. Winsor, excerpted from Rocky Flats Plant report RFP-2866 in Transactions of the American Nuclear Society 1980 Annual Meeting, June 8–June 14, 1980, Las Vegas, Nevada.

Publications

1. *Radiation: What Do We Know About It?,* R. W. Bistline, D. C. Hunt, and R. E. Yoder, Colorado Medicine (March 1980).
2. *Effects of Radiation on Health (External Penetrating Radiation),* R. W. Bistline and R. E. Yoder, Colorado Medicine (May 1980).

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